This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

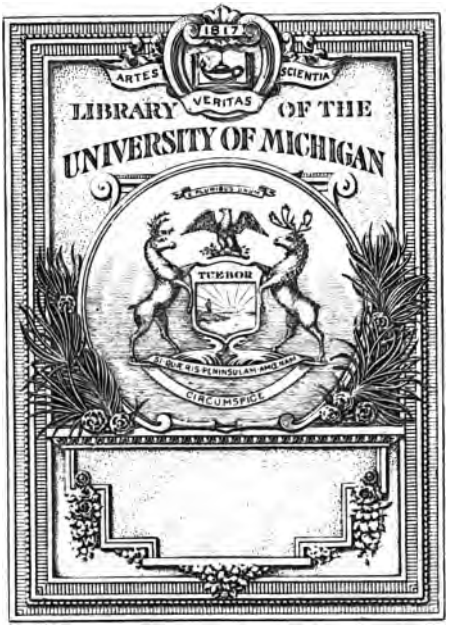
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

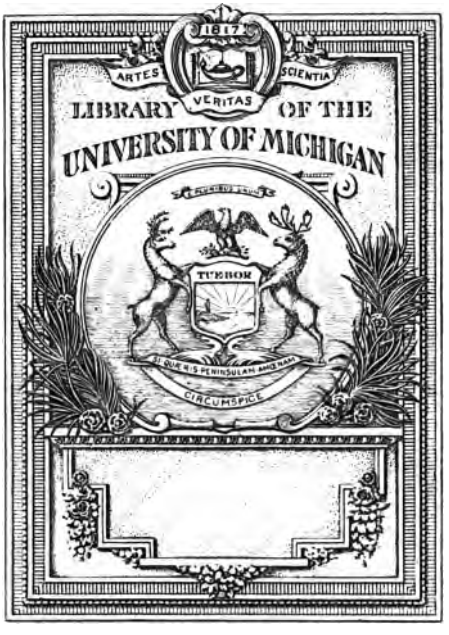
VM
156
.P27

B 1,296,335

c1404


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

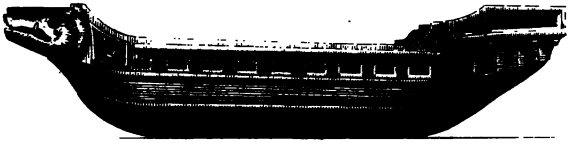
CH


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

1817
ARTES SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

Ancient Trireme.

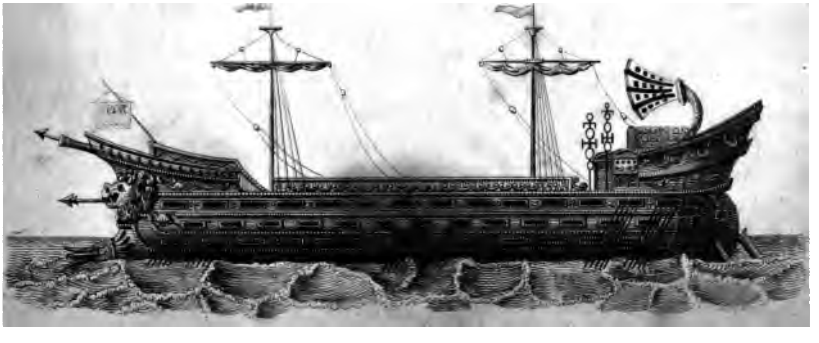
Sheer Draugh of a Roman Galley.



Elevation of Head & Stern.

Midship Section.

A Galley with Forty Banks of Oars.



G. Gladwin fecit

THE

SHIP-BUILDERS'

COMPLETE GUIDE;

COMPREHENDING

THE THEORY AND PRACTICE OF

Naval Architecture,

WITH ITS

MODERN IMPROVEMENTS.

BY CHARLES FREDERICK PARTINGTON,

Author of an Historical and Descriptive Account of the Steam Engine; and one of the Lecturers at the London, Russell, Metropolitan, and Surrey Institutions, Mechanics' Institution, &c. &c.

ILLUSTRATED BY NUMEROUS ENGRAVINGS.

LONDON.

PUBLISHED BY SHERWOOD, GILBERT, AND PIPER,
PATERNOSTER ROW.

1826.

YM
15L
P97

ADVERTISEMENT.

THE following Pages form part of a larger Work, now in course of publication, expressly adapted to the use of operative Artists and Manufacturers, entitled THE MECHANICS' GALLERY OF SIENCE AND ART. This work is not intended merely to form a repository of practical instructions in every branch of the useful and ornamental arts, but also, by exhibiting in a familiar manner their scientific principles, and tracing the history and gradual progress of mechanical knowledge, to open new and enlarged views to the operative Artist.

The other Parts of the MECHANICS' GALLERY already published consist of the following Treatises, all of which are illustrated with appropriate Cuts and Plates :—

1. The CLOCK and WATCH-MAKERS' COMPLETE GUIDE; comprehending the early History of the Art, its progressive Improvement, and present state, Theoretical and Practical. 2*s*.

2. The ENGRAVERS' COMPLETE GUIDE; comprising the Theory and Practice of Engraving, with its modern improvements, in Steel Plates, Lithography, &c. 1*s*.

3. The COACH-MAKERS' and WHEELWRIGHTS' COMPLETE GUIDE; comprehending the Theory and Construction of Wheel Carriages, with their recent improvements. 1*s*.

4. The PRINTERS' COMPLETE GUIDE; containing a sketch of the history and progress of Printing to its present state of improvement; details of its several departments; numerous schemes of Imposition; modern Improvements in Stereotype, Presses, and Machinery.

5. The BUILDERS' COMPLETE GUIDE; comprehending the Theory and Practice of the several Departments of Architecture, Bricklaying, Brickmaking, Masonry, Carpentry, Joinery, Painting, and Plumbing. With a variety of useful Information on the Application and Durability of Materials, &c. 6*s*.

The ensuing Parts will comprise, in succession, the various branches of Mechanical Science in general application; the object of the Editor being to concentrate the best practical information on the different processes of Art, so as to combine all the advantages of a large and extensive Encyclopedia at a comparatively small cost.

CONTENTS.

	Page
Origin of ship building in England	1
Improvements in the 14th and 15th centuries	1
Opinion of Sir Walter Raleigh on the importance of the navy	2
Egyptian and Chinese mode of constructing vessels	3
Marine architecture of ancient Greece	4
Improvements by the Romans	5
Fire-ships of the Tyrians	6
Early Scottish ship of war	7
Modern vessels of the Chinese	7
Names of the classes of vessels composing the British navy	8
First principles of construction	9
Plan of the arrangement of a ship's frame	11
Plan, dimensions, and names of the timbers, of a ship of war	13
Directions for describing the sheer draught	18
——————————half-breadth plan	32
——————————body plan	33
——————————water lines	37
——————————fashion piece and transoms	38
——————————stern post	40
——————————hawse holes	41
——————————in-board works	42
Sir Robert Seppings's improvements	49
Defects of the common mode of ship building	50
Superiority of the new system	53
Properties of the diagonal frame	54
Non-elasticity of ships	55
Tendency to draw asunder	57
General notice of Sir R. Seppings's plan	58
Oblique braces examined	68
New principle for merchant vessels	74
Use of douels	76
Improvement in stowage	78
Approbation of the new stern frame by the lords of the Admiralty	80

Page

M. Dupin on the round stern 84
Flat floor and sliding keel 86
Rules for the measurement of tonnage 94
Hookey's method of bending timber 97
Commencement of the hull, and description 98
The launch 105
Soho and Livingston steam vessels 107
Barges, &c. 108
Modes of constructing life boats 109
Means of removing stranded ships 114
Ballasting vessels 115
Lieutenant Shuldham's boat 116
Mr. Finlayson on ventilation 119
Perkins's Orthometer 121
Preston's improved binnacle 122
Capstan 123
Tables for ascertaining the weight of a cable 126
Anchor 128
Table, shewing the number of anchors allowed each ship in the navy, with their weight and value 132
Causes, means of prevention, and cure of the dry rot . . 133
Glossary of terms used in connection with the practice of ship building 137

THE

SHIP BUILDER'S

COMPLETE GUIDE.

THE navy of England does not date its origin prior to the time of our Saxon ancestors. It is now, however, the best defence for our sea-girt shores. The navy may indeed be considered as the natural strength of the British empire, nor need we apprehend any danger from foreign invasion while Britain retains the sovereignty of the seas. To ensure this important desideratum, the art of ship-building must receive that assistance from theoretical science, without which, foreign navies will ultimately excel us on our own peculiar element.

The first authentic testimony which we find of the birth of the British navy is the invasion of Normandy by Henry, surnamed Beauclerc, in the year 1106; and the crusading expeditions, which immediately followed, contributed, in some degree, to cherish the embryo giant in its youth. Selden has given the event just mentioned as the æra of the first assertion on the part of Britain to the right of, what is called, the dominion of the sea; and adduces, in proof, the orders given by Henry to his Butescarli, or sea officers, that they should take particular care no vessels from Normandy approached the English coast.

The variety of improvements and inventions which had taken place during the fourteenth and fifteenth centuries, tended to render general nautical knowledge much more respectable than it had been. To the invention of the compass is most probably owing the discovery of America. To that of cannon, and their introduction into ships, may be attributed those improvements in naval architecture, which distinguish a modern ship of war, from the ancient galley.

The renowned Sir Walter Raleigh, speaking of the ability and

knowledge possessed by the British shipwrights, observes, "To say the truth, a miserable shame and dishonour it were for our shipwrights, if they did not exceed all others in the setting up of our royal ships, the errors of other nations being far more excusable than ours; for the kings of England have for many years been at the charge to build and furnish a navy of powerful ships, for their own defence, and for war only; whereas the French, the Spaniards, the Portuguese, and the Hollanders, till of late, have had no proper fleet belonging to their prince or state." The same learned person next proceeds to pay the following tribute to the knowledge possessed by foreign countries, who certainly were the predecessors, and perhaps the tutors of Great Britain in this science: "The Venetians only," says he, "have for a long time maintained their arsenals of gallies, and the kings of Denmark and of Sweden have had good ships for these last fifty years. I say that the forenamed kings, and more especially the Spaniards and the Portuguese, have ships of great bulk; not fitter for the merchant, than for the man of war, for burthen than for battle; and, as Popelinize well observes 'the forces of princes by sea are indisputable marks of the greatness of an estate.' Whosoever commands the sea, commands the trade; whosoever commands the trade of the world, commands the treasures of the world, and consequently the world itself: yet can I not deny, but that the Spaniards, being afraid of their Indian fleets, have built some few very good ships; but they have no ships in garrison, as his Majesty hath, and, to say the truth, no sure place to keep them in; but in all invasions, he is driven to take up of all nations which come into his port for trade."

We may now, however, examine some of the earlier and ruder efforts in this important art. The Egyptians will claim an early place in our historical notice of the progress of naval architecture.

The following description is given us of the original method used by the Egyptians in constructing vessels, and it will forcibly strengthen the observation we have already made, that all primitive attempts in the art we are about to treat of, have been regulated or extended more by natural causes and consequences than by any wonderful exertion produced from the mind of the artificer himself. The vessels used on the Nile appear to have been formed of small planks cut out of the acantha or Egyptian thorn: these were not, as might be naturally supposed, cut into lengths, as planks, but nearly square, measuring about three feet each way: they were lapt over each other like tiles, and fastened together by a proper number of wooden pins nearly of the same shape with the treenails of modern times. This mode of

construction was found sufficiently strong for the purposes to which it was applied, even without the obvious assistance of any internal frame of timber, and proving equal to the necessities and ambition of the inventors, they, for a long time, troubled not themselves with attempting any additional improvement.

The hull of the vessel being completed, a competent number of seats, or benches, for the accommodation of the rowers, were added; and when the joints or seams were carefully caulked with the papyrus, so as completely to exclude the water, the floating fabric then became fit for immediate use. We must not, however, forget to mention, that experience very easily suggested the necessity of some directing as well as impelling power, in aid of human labour. A mast, formed out of a strait stick of the acantha, and a sail, made of papyrus, supplied the latter; at the same time a rudder, which is said to have passed through the keel, or bottom of the vessel, remedied the defect occasioned by the want of the former.

Among a people so destitute of ambition as we find the Chinese described, little variation could be expected to take place either in ship-building, or any other art connected in the most distant way with war, and extension of territory, since that time, when experience taught them that their different rude contrivances fully answered the humble ends to which they were applied. On comparing the account given by Sir George Staunton of their smaller vessels with those in use among the aboriginal Britons, the similitude will be found extremely striking. "The boats," says he, "commonly in use among them, consist of five planks only, joined together without ribs or timbers of any kind. Those planks are bent to the proper shape, by being exposed some time to a flame of fire. They are brought to a line at each end, and the edges are joined together with wooden pins, and stitched with bamboo split into flexile threads, and the seams afterwards smeared with a paste made with quick lime from sea-shells and water. Others are made of wickerwork smeared all over, and rendered water-tight by the same composition as is used for the former. The owners affect to paint eyes upon the heads of all those boats, as if to denote the vigilance requisite in the conduct of them. They are remarkable for standing the sudden shock of violent waves, as well as for being stiff upon the water, and sailing expeditiously. The boat belonging to the chief of the district was built upon the same plan, but on a larger scale; had a carved and gilt head bearing some resemblance to that of a tiger; and a stern ornamented with sculpture, and painted with a variety of designs in lively colours. In those boats the

principal sitters are generally at the stem, instead of being near the stern, as is the custom in Europe."

The keel is reported to have been generally omitted during the early ages of navigation; in vessels intended merely for commercial purposes. The form of these, from the most authentic descriptions, appear to have borne greater similitude to those at present employed in the same line among the Hollanders, than to any others now in use. They were flat floored, round, broad, drawing little water, and of very great breadth in proportion to their length, so that they might be capable of containing a larger quantity of commodities, than would be the case under the adoption of any other practised form. Their floor timbers were continuous; and with the addition of one futtock only on each side (called by the Greeks the ribs, or internal part of the animal body) the frame was completed.

Some persons, indeed, have gone so far as to assert, that by a peculiar mode, known only to the ancients, the timber was rendered so flexible, that the frame was formed of one piece only. This secret, however, appears to have been nothing more than bringing it by force into its proper curve, and confining it either till time had, in a great measure, subdued its elastic efforts, to regain its original and naturally straight form; or as a more expeditious method, by adding cross pieces, now called beams, and bolting them strongly to the timbers, completed the vessel by one uninterrupted operation. This practice being soon found extremely laborious and inconvenient, was quickly discontinued with regard to vessels of burthen, and the keel universally and indiscriminately applied to them, as well as to vessels of war. To the keel, improvement and subsequent experience suggested the addition of the keelson, which, confining the heads of the floor-timbers, then in two parts, jointed into and divided by the keel, very materially contributed to the strength and safety of the vessel. Close to the keelson was the well, contrived as the receptacle of all that bilge water, which the working of the vessel through the rough sea caused the admission of, added to the impossibility of closing the joints or seams so completely by caulking, but that, under such circumstances, some must find its way. The part immediately above the keelson was called the hold, and from thence is derived the English word keel, which forms the bottom of it. Aloft, beams were fixed, as already stated, which served to strengthen the vessel, and support that necessary covering well known by the name of deck. The frame, consisting of such timbers as formed the principal strength of the vessel, might now be considered as complete; but if it be fair to give any pre-eminence where two distinct parts

mutually contribute to the support and perfection of each other, that which may be deemed the most material still remains to be described: this is the side, or interior planking of the vessel, which was named by the Greeks after the vest, or garment, with which it was customary to cover the human body.

The principal dimensions of different classes of vessels in use among the ancients, as well as of those which were of such extraordinary magnitude as to be extremely uncommon, and rarely constructed, have been transmitted to posterity with much apparent certainty and precision. The celebrated Egyptian vessel, called the Isis, is said to have been in length one hundred and eighty feet, in breadth forty-five, and in height, from the upper edge of the deck to the bottom of the well, forty-three feet. The well-known ship of Hiero, king of Syracuse, was of nearly four thousand tons burthen. The rules of construction in general use, for those which were usually employed in commerce, after the art had progressively advanced toward, what was then supposed perfection, were in the following proportion:—supposing the breadth twenty-five feet, the length was one hundred. The gallies which were intended entirely for the purposes of war, were twice that length, but of the same breadth; nor can that very extensive difference be deemed incredible, or even wonderful, when it is known, that, even in modern times, vessels, no less extravagantly proportioned, have been built for particular purposes, and have proved by no means ill adapted to them.

Meibomius gives the following dimensions of the ancient Roman Triremes: "They were," says he, "in length one hundred and five feet; in breadth eleven; but, according to new regulations, adopted after the time of Julius Cesar, they were built only ninety feet in length, and ten in breadth: the Quadrireme was one hundred and twenty-five feet long, and thirteen broad: the height of the Octoreme, (as the same author asserts) measured, from the upper surface of the deck to the lower edge of the keel, eleven feet: the Hexereme nine." Their first requisite, as there has already been occasion to remark, was swiftness: on that principally depended the success of all their naval encounters; and every other quality was of little consequence to them. For this reason, the minds of those ingenious men, who considered the science of constructing vessels as a national art, which the well-doing of their country particularly demanded should be carefully cultivated, were constantly applied to the discovery or advancement of some improvement. As soon as it was practically found, that the narrowness of their vessels contributed, in a great degree, to their swiftness, and

this was established as a fixed, an invariable principle, the next care was to dispose the rowers so commodiously within the vessel, that they might not, in the first place, impede each other in their motions, and in the second, that no part of the side should be left vacant where it was possible to employ or work an oar. The attainment to this degree of perfection is attributed to the Sidonians; and the variety of the different services, which repeated warfare created, gave birth to all those different classes into which the ancient galleys were divided.

Curtius gives a very circumstantial account of a fire-ship, equipped by the Tyrians at the time their capital was besieged by Alexander. "Having selected," says the author, "one of the largest gallies they possessed, they loaded it by the stern, with stones, and other ballast, so that the prow became considerably elevated above the surface of the water. The whole of the vessel which was above water was payed very thick with sulphur, and other substances, easily inflammable, which operation being completed, advantage was taken of a wind favourable for the attempt, and all the sails being set, the crew, who in aid of the sails made use of their oars also, directed it towards the mole which Alexander had, with so much difficulty, laboured to construct. When they had approached sufficiently near to the destined object of destruction, the vessel was set on fire, and the crew jumped into boats which had followed for the purpose of receiving them." This project, at that time new in theory as well as practice, proved completely successful: the hopes of Alexander were frustrated, at least for a time, and every trace as to the labour of so many thousand men, vanished almost in an instant, for the whole of the stupendous work was completely destroyed. Nor was it on such an occasion alone as the preceding, that these destructive engines of war, as they might, without impropriety be stiled, were used. Various were the occasions on which they were employed, especially in the attack of fleets when lying in the harbour, for in this particular application of them, the ancients appear to have been most expert.

The following account given of a Scottish ship of war may stand as the summary history of their royal navy:—

"The king of Scotland rigged a great ship called the Great Michael, which was the largest, and of superior strength to any that had sailed from England or France: for this ship was of so great stature, and took so much timber, that except Falkland, she wasted all the woods in Fife, which were oak wood, with all timber that was gotten out of Norway, for she was so strong, and of so great length and breadth, all the wrights of Scotland, yea, and many other strangers, were at her device

by the king's command, who wrought very busily in her, but it was a year and a day ere she was completed. To wit; she was twelve score foot of length, and thirty-six foot within the sides; she was ten foot thick in the wall and boards, on every side so slack and so tight, that no cannon could go through her. This great ship cumbred Scotland to get her to sea. From that time that she was afloat, and her masts and sails complete, with anchors offering thereto, she was counted to the king to be thirty thousand pounds expense by her artillery, which was very great and costly to the king by all the rest of her orders. To wit; she bare many cannon, six on every side, with three great bassils; two behind in her dock, and one before, with three hundred shot of small artillery, that is to say, myand and batterd falcon, and quarter falcon, flings, pestilent serpentens, and double dogs, with hagtor and culvering, crossbows and handbows. She had three hundred mariners to sail her, she had six score of gumers to use her artillery, and had a thousand men of war by her, captains, shippers, and quarter masters."

The Chinese are said, by modern travellers, to build vessels which trade as far as Manilla, Japan, and Batavia, the burthen of which frequently amounts to eight hundred or even a thousand tons. All well-informed writers agree, as already stated, that no alteration has been made in the naval architecture of this extraordinary people for several centuries past; and it has excited their wonder, in no small degree, that though Canton is visited by the ships of various nations, the superior construction of which, it might be apprehended, must be necessarily acknowledged, yet they have never thought proper to adopt any improvement whatever in the art. It is rational, however, to believe, that if no innovation has been made in the form and rigging of their vessels, the size and burden of them has been nevertheless permitted to increase with the spirit of trade and foreign commerce which the example of Europeans cannot but have diffused. This supposition will reconcile the account just given of the tonnage of the modern Chinese vessels, with the seemingly contradictory authority of former visitors, from whom it has been understood that the capacity of the Chinese vessels, or junks, never exceeded three hundred tons.

To the eyes of Europeans, these vessels, whether armed or commercial, are, in form, little varying from flat-bottomed boats, or that particular species called, by Europeans, punts, with two or three masts. Those which are built and equipped for war, are, as might be expected, somewhat better formed for alertness and dispatch than such as are destined for trade alone; but, in other respects, the mode of decoration and general design are nearly similar; the latter being provided

with ports, though seldom with ordnance. The most remarkable features in their hull are the abrupt and flat termination of the prow, together with the total absence of a bow-sprit. In the vessels usually represented in Chinese drawings, a strangely fashioned contrivance answering the purposes of a windlass, is affixed to the outside of the bow, by means of which the anchor is weighed; but this appendage is by no means universal. The prevailing idea among this, as indeed, among almost every other people, respecting the form and decoration of the prow, appears to be that of giving it a rude and general resemblance to the head of an animal; to this end the bows, on each of which is generally painted an eye, with the pupil turned forward, are made to rise like the ears of an owl; while the flat timbers of the stem, forming a species of beak, contribute, in some degree, to increase the singular similarity.

The lower part of the stern is either entirely hollowed in an angular form, or, being flat in its primary construction, has, in its centre, a recess of that description. Within this, is a second hollow, or chamber, rising the whole height nearly from the keel to the bottom of the quarter-gallery, within which the rudder moves, and is protected from the violence of the sea. This rudder is five or six feet in length, and managed by ropes only, one of which fastens to the poop, which occasionally lifts it out of the water, with a view to its preservation.

The first-rate is a ship of the line, of one hundred guns and upwards, having three decks or tiers of guns; and the seventy-four is also of the line, with two decks or tiers of guns. The gun-vessel is rigged like a sloop of war, which is the sixth or smallest rate. The brig has only two masts, which are rigged like the main and fore masts of a ship, but has a fore and aft main-sail. A snow only differs from a brig by having a try-sail, which hoists upon a small mast abaft the main-mast, and thereby can carry a square main-sail. A ketch has two masts, similar to the brig, but has no fore-mast, but a main mast and a mizen-mast rigged as a ship's. The lugger has two masts, with square sails that are hoisted by their yards, not in the middle, as vessels in general, but at one-third of their length. Schooners are vessels of a similar size to luggers, having two masts, whose main-sail and fore-sail are suspended from gaffs at the head; and the foot stretched out by a boom, like a man-of-war's long-boat. Both luggers and schooners sometimes carry top-sails, as the brig. Sloops, or vessels have one mast, have a main-sail, fore-sail, and jib, as the man-of-war's long-boat. Foreign vessels not rigged like the above, are mostly like the zebec.

Stability and "flotation," by which latter term is meant swiftness, being the first and principal points which strike the consideration of the naval architect, other temporary or local considerations follow at an humble distance, "praying their wants to be attended in turn, as soon as the demands of their superiors are satisfied." Stability evidently claims precedence, even before flotation, or speed, because the safety of the human race depends on the former; and only the political or pecuniary advantage of it on the latter. Supposing a vessel drawing six feet water, and having a length of keel amounting to forty feet, it is too evident to need explanation, that such a vessel must make infinitely more leeway, than if it drew twelve feet, or was eighty feet in length; the lateral resistance being encreased according to the squares of the side or surface presented to the water. From this cause is derived the reason, why vessels of great length are less apt to make leeway than those which are shorter. The hope of encreased advantage may, however, be productive of evil, in some respects, provided the system is not properly confined within reasonable bounds. The inconvenience to be dreaded is material, and may be attended with the worst consequences. The reason is easily demonstrable in plain and very few terms. The action of the rudder, and its influence on the motion or course of the vessel, is exactly that of the lever; and if the hull becomes extended to an immoderate length, the force of such lever is gradually weakened, and less capable of effecting its office till, in the end, it becomes totally useless; so that, except its own power is increased by an extraordinary addition, which would be inconvenient, or if very far augmented, impracticable on account of the power required to govern and regulate it; the ship will become the sport of the winds and waves, refusing to obey the wishes and will of its pilot.

To remedy this inconvenience, vessels were introduced, having an exceeding narrow breadth of floor, and built, in every respect, what is termed sharp; so that by their sinking considerably lower beneath the surface of the water than those of flatter construction, they may, though much shorter, continue to present the same face in square inches, or feet, to the fluid as a lateral resistance, and consequently be rendered equally as little liable to fall to leeward. This system of construction is, however, pregnant with quite as many inconveniencies as the former. It experiences infinitely more resistance, in the first instance, in its passage through the water; its very contracted capacity, in proportion to its measurement and expence of construction, renders it inconvenient and unadvisable, even as a vessel of war; and

totally incompatible with the ideas as well as interests of commerce. Added to these considerations is, that scarcely less consequential objection, arising from its great draught of water, its incapability of sailing, where vessels of a flatter construction would be capable of passing, and the extreme danger to which it would be exposed, in case of touching the ground; even in that slight degree which would be unattended even with apprehension, in the instance of a flat-floored vessel.

If we compare the carcase of a ship to the skeleton of the human body, the keel may be considered as the back-bone, and the timbers as the ribs. It, therefore, supports and unites the whole fabric, since the stem and stern-post, which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and inclose the extremities of the sides by transoms; as the keel forms and unites the bottom by timbers. The keel is generally composed of several thick pieces, placed lengthways, which, after being scarfed together, are bolted and clinched upon the upper side. When these pieces cannot be procured long enough to afford a sufficient depth to the keel, there is a strong thick piece of timber bolted to the bottom thereof, called the false keel. The figure of vessels, is an object of great importance, with regard to their motion, sailing, &c.; and in the determining what form is most commodious, the doctrine of infinites becomes of apparent service to navigation and commerce. A body moving in an immovable fluid, is obliged to sever the parts thereof: and they resist such separation.—Now, setting aside a certain tenacity, by which they are, as it were, glued together, and which is different in different fluids; the whole force of the resistance depends on that of the shock, or impulse: for a body that is struck may be said to strike at the same time; but a perpendicular stroke is that which a fluid resists the most readily; and for a body to move freely therein, it must be of such a figure, as to present itself as obliquely as possible. If it were triangular, and moved with the point foremost, it is certain all its parts would strike the fluid obliquely; but they would all strike it with the same obliquity; and it were more advantageous that each should strike more obliquely than the next adjacent. Now, such a perpetual augmentation of obliquity can no where be had in a curve line; each point of which is considered as an infinitely small right line, always inclined to the other little right lines contiguous to it. These brief observations will account for the curvilinear figure assumed by all perfect vessels, to explain the structure of which we now more immediately proceed.

When it is proposed to build a ship, the proportional size of every

part of her is to be laid down; from whence the form and dimensions of the timbers, and of every particular piece of wood that enters into the construction, is to be found. As a ship has length, breadth, and depth, three different plans at least are necessary to exhibit the form of the several parts of a ship; these are usually denominated the sheer-plan, the half-breadth and body-plans.

The sheer-plan or draught, otherwise called the plan of elevation, is that section of the ship which is made by a vertical plane passing through the keel. Upon this plan are laid down the length of the keel; the height and rake of the stem and stern-post; the situation and height of the midship and other frames; the place of the masts and channels; the projection of the head and quarter-gallery, and their appendages; and in a ship of war the position and dimension of the gun-ports. Several imaginary lines namely, the upper and lower height of breadth lines, water lines, &c. are also drawn in this plan.

The half breadth or floor plan, or, as it is frequently called, the horizontal plane, contains the several half breadths of every frame of timbers at different heights; ribbands, water lines, &c. are also described on this plane.

The body-plan, or plane of projection, is a section of the ship at the midship-frame or broadest place, perpendicular to the two former. The several breadths, and the particular form of every frame of timbers, are described on this plane. As the two sides of a ship are similar to each other, it is therefore unnecessary to lay down both; hence the frames contained between the main-frame and the stem are described on one side of the middle line, commonly on the right-hand side, and the after frame are described on the other side of that line.

Several lines are described on these planes, in order the more readily to assist in the formation of the timbers; the principal of which are the following:

The top-timber line, is a curve limiting the height of the ship at each timber.

The top-timber half-breadth line, is a section of the ship at the height of the top-timber line, perpendicular to the plane of elevation.

The height of breadth lines, are two lines named the upper and lower heights of breadth. The lines are described on the plane of elevation to determine the height of the broadest part of the ship at each timber; and being described in the body-plan, limits the height and breadth of each frame at its broadest part.

The main half-breadth, is a section of the ship at the broadest part,

perpendicular to the sheer-plan, and represents the greatest breadth at the outside of every timber.

Water-lines, are lines supposed to be described on the bottom of a ship, when afloat, by the surface of water, and the uppermost of these lines, or that described by the water on the ship's bottom when sufficiently loaded, is called the load water-line. According as the ship is lightened, she will rise higher out of the water; and hence new water-lines will be formed. If she be lightened in such a manner that the keel may preserve the same inclination to the surface of the water, these lines will be parallel to each other; and if they are parallel to the keel, they will be represented by straight lines parallel to each other in the body-plan; otherwise by curves. In the half-breadth plan, these lines are curves limiting the half-breadth of the ship at the height of the corresponding lines in the sheer-plan. In order to distinguish these lines, they are usually drawn in green.

Ribband lines, are curves on a ship's bottom by the intersection of a plane inclined to the plane of elevation: and are denominated diagonal or horizontal, according as they are measured upon the diagonal, or in a direction perpendicular to the plane of elevation. Both these answer to the same curve, on the ship's bottom, but give very different curves when described on the half-breadth plan.

Frames, are circular pieces of timber bolted together and raised upon the keel at certain distances, and to which the planks are fastened. A frame is composed of one floor-timber, two or three futtocks, and a top-timber on each side: which being united together, form a circular inclosure, and that which incloses the greatest space is called the midship or main-frame. The arms of the floor timber of this frame form a very obtuse angle; but in the other frames this angle decreases with the distance of the frame from midships. Those floor-timbers which form very acute angles are called crutches. The length of the midship floor-timber is in general about half the length of the main-frame.

A frame of timbers is commonly formed by arches of circles called sweeps. There are generally five sweeps: 1st. The floor-sweep, which is limited by a line in the body-plan perpendicular to the plane of elevation, a little above the keel; and the height of this line above the keel at the midship-frame is called the dead-rising. The upper part of this arch forms the head of the floor-timber. 2d. The lower breadth sweep; the centre of which is in the line representing the lower height of breadth. 3d. The reconciling sweep. This sweep joins the two former, without intersecting either; and makes a fair curve from

Eighty Gun Ship.

the lower height of breadth to the rising line. If a straight line is drawn from the upper edge of the keel to touch the back of the floor sweep, the form of the midship-frame below the lower height of breadth will be obtained. 4th. The upper breadth sweep; the centre of which is in the line representing the upper height of breadth of the timber. This sweep described upwards forms the lower part of the top-timber. 5th. The top-timber sweep is that which forms the hollow of the top-timber. This hollow is, however, very often formed by a mould, so placed as to touch the upper breadth sweep, and pass through the point limiting the half-breadth of the top-timber.

The consideration of these three principal plans, already described, is so much the more important, as it comprehends a sufficient knowledge of the figures of all vessels. For, although these three plans do not really determine the figure of the vessel, and may belong to an infinity of different kinds, yet all these differences cannot exceed certain limits sufficiently confined; so that whatever idea we might form of the figure of the vessel, it cannot deviate considerably from the truth.

In order to explain this the better, we will proceed to construct the sheer-draught, and here the nature, and all the properties of the vessel, according to her design, for war or commerce, must be taken into consideration, upon which the whole theory of the art depends: such are, capacity, stability, velocity, and ease in the sea or at anchor. These properties are not to be adopted merely from speculative theory, but from those that have actually been demonstrated by repeated experiments. That our readers may have the clearest conception of the various parts of a ship, we will endeavour to describe them in as familiar a manner as possible; introducing also all that is necessary to be known as we proceed.

We may commence by shewing the mode of describing the several plans of a ship of war, proposed to carry eighty guns upon two decks. The dimensions will be as follows.

	Feet.	*Inches.*
Length on the gun or lower deck from the aft part of the rabbet of the stem to the aft part of the rabbet of the post.	182	0
Length from the foremost perpendicular to dead-flat . . .	63	11¾
Length from the foremost perpendicular to next timber . .	4	0
Length from after perpendicular to timber 37	3	4
Room and space of the timbers	2	8¾
Length of the quarter-deck from the aft part of the stern .	95	0
Length of the forecastle from the fore part of the beak-head	49	0
Length of round-house deck from the aft part of the stern .	51	8

Eighty Gun Ship.

	Feet.	Inches.
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at dead-flat . . .	24	0
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at foremost perpendicular	26	0
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at after perpendicular	26	3
Height from the upper side of the gun-deck plank to the under side of the deck plank, all fore and aft	7	0
Height from the upper side of the upper deck plank to the under side of the greater deck plank . . afore.	6	10
abaft.	6	11
Height to the under side of forecastle plank afore and abaft	6	6
Height from the upper side of the quarter-deck plank to the under side of the round-house plank . . . afore.	6	9
abaft.	6	10
Height of the lower edge of the main wales at foremost perpendicular	24	6
Height of the lower edge of the main wales at dead-flat . .	20	0
Height of the lower edge of the main wales at after perpendicular	26	6
Height of the lower edge of the channel wales at foremost perpendicular	32	6
Height of the lower edge of the channel wales at dead-flat .	29	0
Height of the lower edge of the channel wales at after perpendicular	34	0
Height of the upper side of the wing-transom	28	4
Height of the touch of the lower counter at the midde line .	33	5
Height of the touch of the upper counter at the middle line	36	2
Height of the top-timber line at the after part of the stern timber	44	7
Main wales in breadth from lower to upper edge	4	6
Channel wales in breadth from lower to upper edge . . .	3	0
Waist rail in breadth	0	7
Distance between the upper edge of the channel wales and the under edge of the waist rail	2	9
Sheer rail in breadth	0	6
Distance between the sheer rail and the rail above from timber 13 to the stern	2	5
Distance between the sheer rail and the rail above from timber 7 to timber 11	1	4
Distance between the sheer rail and the rail above to the forepart of beak-head	1	2
And the said rail to be in breadth	0	6

Eighty Gun Ship.

	Feet.	Inches.
Plank sheer to be in thickness	0	2½
Centres of the mast.—From the foremost perpendicular to the centre of the mainmast on the gun-deck	103	2
From the foremost perpendicular to the centre of the foremast on the gun-deck	20	5
From the after perpendicular to the centre of the mizenmast on the gun-deck	28	6
Height of ditto from the upper edge of the keel	26	1
Stem moulded	1	3
Foremost part of the head afore the perpendicular	2	4
Height of ditto from the upper edge of the keel	38	3
Aft part of the rabbet afore the perpendicular on the upper edge of the keel	3	4
Aft part of the port abaft the rabbet at the upper edge of the keel	2	6
Aft part of the port abaft the rabbet at the wing-transom	1	1
Stern-post fore and aft on the keel	3	1
Ditto square at the head	2	0½
The touch of the lower counter at the middle line, abaft the aft part of the wing-transom	7	6
Round aft of the lower counter	1	4
Round up of the lower counter	0	9
The touch of the upper counter at the middle line abaft the aft part of the wing-transom	9	9
Round aft of the upper counter	1	3½
Round up of the upper counter	0	10
Aft part of the stern-timber at the middle line, at the height of the top-timber line, abaft the aft part of the wing-transom	12	6
Round aft of the wing-transom	0	6
Round up of the wing-transom	0	5½
Load draught of water from the upper edge of the keel { afore.	20	5
{ abaft.	20	5
The channel to be in length	37	0
And in the thickness at the outer edge	0	4½
The dead eyes to be 12 in number, and in diameter	1	6
Foremost end of the main channel afore timber	0	10
The channel to be in length	38	0
And in the thickness at the outer edge	0	4½
The dead eyes to be 14 in number, and in diameter	1	6

Dimensions.	Feet.	Inches.
Foremost end of the mizen-channel abaft timber 27	2	4
The channel to be in length	20	0
And in thickness at the outer edge	0	4
The dead eyes to be 7 in number, and in diameter	1	0

Dimensions of the several parts of the Bodies.

Fore Body.	Timbers Names.													
	Θ		C		G		L		P		T		W		Y	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	F.	In.	Ft.	In.	Ft.	In.
Lower height of breadth	22	2	22	6	22	7	23	0	23	11	25	7	26	10	28	8
Upper height of breadth	24	10	24	10	24	10	24	10½	25	3½	26	4½	27	4½	29	0
Height of the top-timber line	37	5	37	7	38	0	38	5	39	1	39	10	40	4	40	9
Height of the rising line*	0	0	0	5½	3	10	9	10	18	6						
Height of the cutting down	2	3½	2	3½	2	3½	2	8	3	10	6	4				
Main half breadth	24	5½	24	5½	24	4½	24	0½	23	2½	20	2	17	0	11	0½
Top-timber half breadth	20	11	20	10	20	9	20	6	20	0	18	9½	17	10	16	6
Half breadth of the rising	8	7	8	4	6	5½	2	9	5	7						
									Outside							
Length of the lower breadth sweep	19	2	18	9	18	3	17	3	15	11	14	1	12	7	12	0
First diagonal line	7	9	7	8½	7	7	7	1	6	3	3	8				
Second ditto	13	9	13	8½	13	4½	12	1	10	3	7	1½	4	6		
Third ditto	20	0	19	11	19	2	17	7	15	1	11	1	8	3½	3	4½
Fourth ditto	23	4½	23	4½	23	0	21	8½	18	11	14	8½	11	5	6	0
Fifth dito	24	8	24	8	24	4½	23	5½	21	2½	17	1	13	8½	7	11
Sixth ditto																
Seventh ditto	24	11½	24	11½	24	0	23	9	22	10	20	10½	18	6½	14	7

* Rising height 11 feet 10 inches at dead-flat, from which all the other risings must be set off.

AFTER BODY.	TIMBERS NAMES.																							
	1		5		9		13		17		21		25		29		33		35		37			
	Ft.	In.	Ft.	In.	Ft.	In!	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.		
Lower height of breadth . . .	22	6	22	6	22	6	20	7½	22	9	23	0½	27	7½	24	6	25	10¾	26	9¾	28	3		
Upper ditto	24	10	24	10	24	10	24	11	25	1	25	4	25	8	26	3	27	1	27	9	28	8		
Height of the top timber line .	37	5	37	5	37	6	37	10	38	3½	38	11	39	8	40	6	41	5	42	0	42	6		
Height of the cutting down . .	2	3½	2	3½	2	3½	2	3½	2	4	2	7½	3	5	5	2½	8	7						
Height of the rising	0	2½	0	8½	1	9½	3	6½	6	0	10	1	17	0										
Main half breadth	24	5¼	24	4¾	24	4¼	24	3¼	24	1	23	8½	23	0½	21	10								
Half breadth of the rising . . .	8	6	8	3	7	9	6	10½	5	3½	2	8	2	6	Outside									
Top-timber half breadth . . .	20	11	20	10	20	9½	20	9	20	7	20	3	19	5	18	2	16	8	15	10½	15	0½		
Topsides half breadth											19	7	18	4	17	0	15	10	14	11	14	3		
Length of lower breadth sweeps .	19	2	19	2	19	0	18	7	17	1	16	0	14	5	12	5	9	10½	7	11	4	8		
First diagonal	7	9	7	8½	7	7	7	5	7	2¼	6	7	5	9	4	7	2	10	1	8½	0	7		
Second ditto	13	9	13	8½	13	6	13	1	12	6	11	2	9	7	7	7	4	8¼	3	1	0	11		
Third ditto	20	0	19	11¼	19	7½	19	0	18	1½	16	6	14	2	11	5½	7	8½	5	5	2	1½		
Fourth ditto	23	4½	23	3	23	1½	22	6½	21	11	20	3	18	0½	15	3½	11	4	8	7	4	6½		
Fifth ditto	24	8	24	7	24	6	24	1½	23	6½	22	3½	20	6½	18	2	14	4	11	5	7	0		
Sixth ditto																	18	8½	16	0	11	8		
Seventh ditto											23	9½	23	0	21	8½	20	0	18	11	17	8¾		

Diagonal lines for both the fore and after Bodies.

Fore and after Bodies.	Names of the Diagonal lines.						
	1st.	2d.	3d.	4th.	5th.	6th.	7th.
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
Height up the middle line	6 11	11 4	16 5½	20 8	23 5½	27 5	43 9
Distance from the middle line on the lower base line	4 8	9 1	15 6				
Height up the middle line				0 9½	6 7	12 7½	32 8½

Of the Sheer Draught.

Draw a straight line to represent the upper edge of the keel, erect a perpendicular on that end to the right, and from thence set off 182 feet, the length on the gun-deck, and there erect another perpendicular, that to the right is called the foremost perpendicular, and the other the after one: upon these two perpendiculars all the foremost and aftermost heights must be set off, which are expressed in the dimensions.

Then set off the distance of the main frame, or dead flat from the foremost perpendicular, and at that place erect a third perpendicular, which must be distinguished by the character ⊖. From the dead flat the room and space of all the timbers must be set off; but it will only be necessary to erect a perpendicular at every frame timber; which in the fore body are called dead flat, A, C, E, &c. and in the after body 1, 3, 5, &c. hence the distance between the frame perpendiculars will be double the room and space expressed in the dimensions. Then set off the heights of the gun-deck afore at midship or dead flat, and abaft from the upper side of the keel; and a curve described through these three points will be the upper side of the gun-deck. Set off the thickness of the gun-deck plank below that; and another curve being drawn parallel to the former, the gun-deck will then be described at the middle line of the sheer plan.

The centre of the stern is then to be laid down by means of the table of dimensions; from which centre, with an extent equal to the nearest distance of the upper edge of the keel, describe a circle upwards: describe also another circle as much without the former as the stem is moulded. Then set off the height of the head of the stem, with the distance afore the perpendicular, and there make a point; and within that set off the moulding of the stem, and there make another point: from this last-mentioned point, let a line pass

downwards, intersecting the perpendicular at the height of the gun-deck, and breaking in fair with the inner circle, and the after part of the stern is drawn. Draw another line from the foremost point downwards, parallel to the former, and breaking in fair with the outer circle; then the whole stem will be formed, except the after or lower end, which cannot be determined till hereafter.

The stern-post must be next formed. Set off on the upper edge of the keel, a spot for the aft part of the rabbet taken from the dimensions, and from that forward set off another point at the distance of the thickness of the plank of the bottom, which is four inches and a half; and from this last-mentioned point draw a line upwards, intersecting the perpendiculars at the height of the lower deck; then set up the perpendicular the height of the wing transom, and draw a level line, and where that line intersects, the line first drawn will be the aft side of the wing transom; on the upper part of the middle line set off from that place the distance of the after side of the stern-post; set off also the distance of the after part from the rabbet on the upper edge of the keel, and a line drawn through these two points, will be the aft side of the post. A line drawn parallel to the first drawn line, at the distance of four inches and a half, the thickness of the plank on the bottom, will be the aft side of the rabbet: and hence the stern-post is described, except the head, which will be determined afterwards.

From the dimensions, take the several heights of the upper deck above the gun-deck, afore, at midship, and abaft, and set them off accordingly; through these points describe a curve, which will be the under side of the upper deck; describe also another curve parallel thereto, at the distance of the thickness of the plank, and the upper deck will be then represented at the middle line of the ship.

Set off the height of the lower counter, at the middle line, from the upper edge of the keel, and draw a horizontal line with a pencil; then on the pencil line, set off the distance the touch of the lower counter is abaft the aft side of the wing transom: from this point to that where the fore part of the rabbet of the stern-post intersect, the line drawn for the upper part of the wing transom, draw a curve at pleasure, which curve will represent the lower counter at the middle line. The height of the upper counter is then to be set off from the upper edge of the keel, and a horizontal line is to be drawn as before, setting off the distance, the touch of the upper counter is abaft the side of the wing transom; and a curve described from

thence to the touch of the lower counter will form the upper counter at the middle line.

Both counters being formed at the middle line, the upper part of the stern timber above the counters, is to be described as follows: on the level line drawn for the upper side of the wing transom, set off the distance of the aft side of the stern timber at the middle line, from the aft side of the wing transom, at the height of the top-timber line, and erect a perpendicular: then upon this perpendicular, from the upper edge of the keel, set off the height at the middle line of the top-timber line, at the after side of the stern timber; through this point draw a straight line to the touch of the upper counter, and the upper part of the stern timber will be described.

As the stern rounds two ways, both up and aft, the stern timber at the side will consequently alter from that at the middle line, and therefore remains to be represented. Take the round up of the upper counter from the dimensions, and set it below the touch at the middle, and with a pencil, draw a level line; take also the round aft, and set it forward from the touch on the touch line, and square it down to the pencil line last drawn, and the point of intersection will be the touch of the upper counter at the side. In the same manner find the touch of the lower counter; and a curve, similar to that at the middle line, being described from one touch to the other, will form the upper counter at the side.

Take the round up of the wing transom, and set it off below the line before drawn for the height of the wing transom, and draw another horizontal line in the pencil: then take the round aft of the wing transom, and set it forward on the upper line from the point, representing the aft side of the wing transom; square it down to the lower line, and the intersection will be the touch of the wing transom; then a curve, similar to that at the middle line, being drawn from the touch of the wing transom to the touch of the lower counter at the side, will be the lower counter at the side. Draw a line from the upper counter upwards, and the whole stern timber at the side will be represented. But as the straight line drawn for the upper part of the side timber should not be parallel to that at the middle line, its rake is therefore to be determined as follows.

Draw a line at pleasure, on which set off the breadth of the stern at the upper counter; at the middle of this line, set off the round aft of the upper counter; then through this point and the extremities of the stern, describe a curve. Now take the breadth of the

stern at the top-timber line, and through the point where that breadth will intersect the curve for the round aft of the stern, draw a line parallel to that first drawn, and the distance from the line last drawn, to the curve at the middle of the line is the distance that the side timber must be from the middle line, at the height of the top-timber line.

The sheer is to be described, which is done by setting off the heights afore, at midships and abaft; and a curve described through these three points will be the sheer. But, in order that the sheer may correspond exactly with the dimensions laid down, it will be necessary to proceed as follows: the perpendicular representing the timber dead flat being already drawn, set off from that the distances of the other frame timbers, which is double the room and space, as the frame are only every other one; and erect perpendiculars, writing the name under each: then on each of these perpendiculars, set off the corresponding heights of the top-timber line, taken from the table of dimensions for constructing the bodies; and through these points a curve being described, will represent the sheer of the ship or top-timber line agreeable to the dimensions.

The quarter-deck and forecastle are next to be described, which may be done by taking their respective heights and lengths from the dimensions, and describing their curves. In the same manner also, the round-house may be drawn. The decks being described representing their heights at the middle, it is then necessary to represent them also at the side. For this purpose take the round of the decks from the dimensions, and set them off below the lower line drawn for the middle; and a curve described both fore and aft, observing to let it be rather quicker than the former, will be the representation of the deck at the side.

The ports come next under consideration. In the placing of them due attention must be paid, so as to preserve strength; or that they shall be so disposed as not to weaken the ship in the least, which is often done by cutting off principal timbers, placing them in too large openings, having too short timbers by the side of them, &c. The frames represented by the lines already drawn must be first consulted. Then with a pencil draw two curves, for the lower and upper parts of the lower deck posts, parallel to the line representing the lower deck; the distances of these lines from the deck are to be taken from the dimensions, observing, however, to add to these heights the thickness of the deck, as the deck line at the side represents the under part of the deck.

The foremost port is then to be described, observing to place it as far aft as to give sufficient room for the manager: the most convenient place will therefore be put to it between the frames R and T, and equally distant from each. It will then be placed in the most conspicuous point of strength, as it will have a long top timber on the aft-side, and a long fourth futtock on the fore side of it. The second port may be placed in like manner between the two next frames, which will be equally well situated for strength as the former; and by proceeding in this manner, the ports on the gun-deck may also be placed, taking care to have two frames between every two ports, all fore and aft.

The upper deck ports are then to be described; and in order to dispose of them in the strongest situation possible, they must be placed over the middle between the gun-deck ports, so that every frame in the ship will run up to the top of the side, by their coming between a gun and upper deck port; and every port will be between the frames, which will in a great measure contribute towards the strength of the ship. With regard to the ports on the quarter deck, it is not of such material consequence if they cut the head of the frame, as in placing them the situation of the dead eyes must be considered, placing a port where there is a vacancy between the dead eyes large enough to admit of one; observing always to place them as nearly as possible at equal distances from each other; and where it happens that they do not fall in the wake of a frame, then that frame must by all means be carried up to the top of the side.

The necessary length of the round-house being determined in the dimensions, it may be set off; observing, however, to let it be no longer than is just sufficient for the necessary accommodation of the men, as the shorter the round-house, the works abaft may be kept lower, and a low stern is always considered the best. Then set off the round of the deck at the foremost end, below the line drawn; the deck at the side may be described by another curve drawn quite aft. Now, from the point for the round of the deck to the stern timber, draw a curve parallel to the top-timber line, and that will be the extreme height of the top of the side abaft, which height continues to range fair along to the foremost end of the round-house, and at that place may have a fall about 14 inches, which may be turned off with a drift scroll. At the fore part of the quarter-deck, the top-side may have a rise of 14 inches, which may be turned off also with a scroll. But as the rising of the top-side only 14 inches at that place will not be sufficient to unite with the heights abaft, it will therefore

be necessary to raise 14 inches more upon that, and break it off with a scroll inverted on the first scroll, and continue these two lines, parallel to the top-timber line, to the distance of about seven feet aft. At the foremost end of the round-house there is a break of 14 inches already mentioned; and in order to make that part uniform with the breaks at the foremost end of the quarter-deck, there must be set down 14 inches more below the former; and at these two heights continue two curves parallel to the top-timber line, from the aft part of the stern to the ends of the two curves already drawn at the foremost end of the quarter-deck. If they should happen not to break in fair with them, they must be turned off with a round; but to make them appear handsome, the lower line may be turned off with a scroll. These lines being drawn will represent the upper edges of the rails.

The height of the top side at the fore part of the ship must next be considered; which, in order to give proper height for the forecastle, must have a rise there of 14 inches, the break being at the after end of the forecastle, and turned off as before. But as this part of the ship is still considerably lower than the after part, it will be necessary to give another of eight inches upon the former, and turn it off with a scroll inverted. Hence this part of the ship will appear more uniform to the after part.

The finishing parts, namely the wales, stern, head, rails, &c. remain to be described. The wales may be first drawn; and as the strength of the ship depends very much on the right placing of them, great care must therefore be taken that they may be as little as possible wounded by the lower deck ports, and so placed that the lower deck bolts shall bolt in them, and also that they come as near as possible on the broadest part of the ship. In the first place, therefore, the height of breadth lines must be chosen for our guide. These heights of breadth are to be taken from the dimensions, and set off on the respective frames, and curves drawn through these points will be the upper and lower heights of breadth of lines. The height of the wales may now be determined; which in general is in such a manner, that the upper height of breadth line comes about six inches below their upper edge, and the wales are then placed right upon the breadth lines. Take the heights and breadths of the wales afore, at midships, and abaft from the table of dimensions; draw curves through the points thus found, and the wales will be represented.

The channel wales are then to be described. They are principally

intended to strangthen the top side, and must be placed between the lower and upper deck ports; and the lower edge of them at midships should be placed as low as possible, in order to prevent them from being cut by the upper deck ports afore and abaft. Take their heights and breadths from the dimensions; lay them off, and describe curves through the corresponding points, and the channel wales will be represented.

Lay off the dimensions of the waste rail, and through the points draw a line parallel to the top-timber line all fore and aft. This rail terminates the lower part of the paint work in the top side, as all the work above this rail is generally painted, and the work of the top side below it payed with a varnish, except the main wales, which are always payed with pitch.

Take the draught of water from the dimensions, and draw the load water line, which is always done in green. Divide the distance between the load water-line and the upper edge of the keel into five equal parts, and through these points draw four more water lines.

Set off the centres of the masts on the gun-deck; their rake may likewise be taken from the dimensions. Set off also the centre of the bowsprit, letting it be four feet from the deck at the after part of the stem, which will give sufficient height for a light and airy figure.

Draw the Knight-heads so as to be sufficiently high above the bowsprit to admit of a chock between them, for the better security of the bowsprit. The timber heads may also be drawn above the forecastle, observing to place the most convenient for the timbers of the frame, being those which come over the upper deck ports, as they may be allowed long enough to form handsome heads. There should be one placed abaft the cat-head, to which the foremost block is to be bolted, and there may be two ports on the forecastle formed by them, and placed where it is most convenient to the dead eyes.

Describe the channels, taking their lengths and thicknesses from the dimensions, and place their upper edges well with the lower edge of the sheer rail. The dead eyes may then be drawn, observing to place them in such a manner, that the chains may not interfere with the ports; and the preventer plates must all be placed on the channel wales, letting them be of such a length that the prevention bolt at each end may bolt on each edge of the channel wales. It must also be observed to give each of the chains and preventer plates a proper rake, that is, to let them be in the direction of the shrouds, which may be done in the following manner: produce the mast upwards, upon which set off the length of the mast to the lower part of the

head; these straight lines drawn from that point through the centre of each dead eye, will give the direction of the chain and preventer braces.

The fenders may be then drawn, observing to place them right abreast of the main hatchway, in order to prevent the ship's side from being hurt by whatever may be hoisted on board. The proper place for them will therefore be at timber 3; and the distance between them may be regulated by the distance between the ports. The chest-tree may also be drawn, which must be placed at a proper distance abaft the fore-mast, for the conveniency of hauling home the fore tack. It may therefore be drawn at the aft-side of timber C, from the top of the side down to the upper edge of the channel wales; and the fenders may reach from the top of the side down to the upper edge of the main wales. As the fenders and chest-tree are on the outside of the planks, wales, &c. the lines representing the wales, &c. should not be drawn through them.

Draw the steps on the side, which must be at the fore part of the main drift or break, making them as long as the distance between the upper and lower deck ports will admit of. They may be about six inches asunder, and five inches deep, and continued from the top of the side down to the middle of the main wales.

In order to describe the head, the height of the beak-head must be first determined, which may be about two feet above the upper deck. At that place draw a horizontal line, upon which set off the length of the beak-head, which may be 7½ feet abaft the fore part of the stem, and from thence square a line up to the forecastle deck; which line will represent the aft part of the beak-head, and will likewise terminate the foremost end of the forecastle. The length of the head may now be determined, which by the proportions will be found to be 15 feet six inches from the fore part of the stem. Set it off from the fore part of the stem, and erect a perpendicular, which will be the utmost limits of the figure forward: then take the breadth of the figure from the proportions, which is four feet four inches, and set it off forward; and another perpendicular being drawn will shew the utmost extent of the hair bracket forward, or aft part of the figure. Then draw the lower cheek, letting the upper edge be well with the upper edge of the main wales, and the after-end ranging well with the beak-head line; set off the depth of it on the stem, which is about 11 inches, and let a curved line pass from the after end through the point on the stem, and to break in fair with the perpendicular first

drawn for the length of the head, the fore part of the curve will then represent the position of the figure.

The upper cheek may be next drawn; but, in order to know the exact place of it in the stem, the place of the main rail must first be set off on the stem, the upper edge of which may be kept on a level with the beak-head; then setting off the depth of it below that, the place for the upper cheek may be determined, letting it be exactly in the middle, between that and the lower cheek: then, by drawing curves for the upper and lower edges of the cheek from the after end parallel to the lower cheek, to break in fair with the perpendicular, drawn for the back of the figure: then the upper cheek will be formed. The upper part may run in a serpentine as high as where the shoulder of the figure is supposed to come, at which place it may be turned off with a scroll. The distance from the scroll to the heel of the figure is called the hair-bracket.

The head of the block may be formed, by continuing the line at the breast round to the top of the hair-bracket, observing to keep the top of it about six inches clear of the under side of the bowsprit.

Having the distance set off on the stem for placing the main rail, it may next be described, keeping the bag of it as level as possible for the conveniency of the gratings, and letting the foremost end rise gradually according to the rise of the upper cheek and hair-bracket, and may turn off on the round of the scroll before drawn for the hair-bracket. To form the after end, set off the size of the head of the rail abaft the beak-head line, and erect a perpendicular; then describe the arch of a circle from that perpendicular to break in fair with the lower side of the rail in the middle, and also another from the beak-head perpendicular, to break in favour with the upper side of the rail at the middle, observing to continue the head of it sufficiently high to range with the timber heads above the forecastle.

The head timbers are next to be drawn, placing the stem timber its own thickness abaft the stem, and the foremost must be so placed that the fore side may be up and down with the heel of the block or figure, which has not yet been set off. Take therefore the distance from the breast to the heel on a square which is 7 feet, and erect a perpendicular from the lower part of the upper cheek; which perpendicular will terminate the foremost end of the lower cheek and the heel of the figure, and will also terminate the lower end of the hair-bracket: then, by continuing the same perpendicular from the upper part of the lower deck to the under part of the main rail, the fore side

of the foremost head timber will be described; and by setting off its thickness aft, the other side may be drawn. The middle head timber may be spread between the two former ones: and there may also be one timber placed abaft the stem, at a distance from the stem, equal to that between the others, and the lower end of it may step on the upper edge of the lower rail.

To describe the middle and lower rails, divide the distance between the lower part of the main rail and the upper part of the upper cheek equally at every head timber; and curves being described through these points will form the middle and lower rails. The after end of the lower rail must terminate at the after edge of the after head timber.

The cat-head ought to be represented in such a manner as to come against the aft side of the head of the main rail, to rake forward four inches in a foot, and to steeve up five and a half inches in a foot, and about one foot six inches square. The lower part of it comes on the plank of the deck at the side, and the supporter under it must form a fair curve to break in with the after end of the middle rail.

The hawse holes must come between the cheeks, which is the most convenient place for them; but their place fore and aft cannot be exactly determined until they are laid down in the half-breadth plan.

The knee of the head is to project from the breast of the figure about two inches; and particular care must be taken in forming it downwards that it be not too full, as it is then liable to rub the cable very much: it may therefore have no more substance under the lower cheek at the heel of the figure than is just sufficient to admit of the bobstay holes, and may be three and a half feet distant from the stem at the load-water line, making it run in an agreeable serpentine line from the breast down to the third water line, where it may be one and a half feet from the stem. By continuing the same line downwards, keeping it more distant from the stem as it comes down, the gripe will be formed. The lower part of it must break in fair with the under part of the false keel; and the breadth of the gripe at the broadest place will be found by the proportions to be four and a half feet. As the aft part of the gripe is terminated by the fore foot, or foremost end of the keel, it will now be proper to finish that part as follows: from the line representing the upper edge of the keel, set down the depth of the keel, through which draw a line parallel to the former, and it will be the lower edge of the keel. From that point, where the aft side of the stem is distant from the upper edge of the keel by a quantity equal to the breadth of the keel at midships, erect

a perpendicular, which will limit the foremost end of the keel; and the after or lower end of the stem may be represented by setting off the length of the scarf from the foremost end of the keel, which may be six feet. Set down from the line representing the upper edge of the keel the thickness of the false keel, which is seven inches, and a line drawn through the point parallel to the lower edge of the keel will be the under edge of the false keel, the foremost end of which may be three inches afore the foremost end of the main keel.

The head being now finished, proceed next to the stern, the side and middle timbers of which are already drawn. From the side timber set off forward 14 feet, the length of gallery, and draw a pencil line parallel to the touch of the upper counter at the side, producing it forwards parallel to the sheer as far as the pencil line first drawn; and this line will represent the upper edge of the gallery rim. From which set down eight inches, the breadth of the gallery rail, and draw the lower edge of the rail. At the distance of eight inches from the fore side of the side timber, draw a line parallel thereto; and from the point of intersection of this line with the upper edge of the gallery rim, draw a curve to the middle timber parallel to the touches of the upper counter, which line will represent the upper edge of the upper counter rail as it appears on the sheer draught. The lower edge of this rail may be formed by setting off its depth from the upper edge. In the same manner the lower counter rail may be described: then take the distance between that and the upper counter rail, and set it off below the rim rail; and hence the rail that comes to the lower stool may be drawn, keeping it parallel to the rim rail. Underneath that, the lower finishing may be formed, making it as light and agreeable as possible.

Set off from the middle timber on the end of the quarter-deck, the projection of the balcony, which may be about two feet, and draw a line with a pencil parallel to the middle timber. On this line set off a point one and a half inches below the under side of the quarter-deck, from which draw a curve to the side timber parallel to the upper counter rail, which curve will represent the lower side of the foot space rail of the balcony as it appears in the sheer draught.

Take the distance between the point of intersection of the upper edge of the upper counter with the middle line, and the point of intersection of the under side of the foot space rail with the middle line, which set up on a perpendicular from the upper edge of the rim rail at the foremost end. Through this point draw a line parallel to the rim rail to intersect the lower part of the foot space rail, and this line

will represent the lower edge of the rail that comes to the middle stool, and will answer to the foot space rail. Then between this line and the rim rail three lights or sashes may be drawn, having a muntin or pillar between each light of about 14 inches broad, and the lower gallery will be finished. Set off the depth of the middle stool rail above the line already drawn for the lower edge, and the upper edge may be drawn. Then set off the same depth above the curve drawn for the lower edge of the foot space rail, and the upper edge of that rail may then be drawn.

The quarter-piece must next be described, the heel of which must step on the after end of the middle stool. Draw a line with a pencil parallel to the timber, and at a distance therefrom, equal to the projection of the balcony. Upon this line set off from the round-house deck the height of the upper part of the stern or taff-rail, which may be four feet above the deck. At that height draw with a pencil a horizontal line, and from its intersection with the line first drawn describe a curve to the middle stool rail, observing to make the lower part of this curve run nearly parallel to the side timber, and the lower part about three inches abaft the side timber; and this curve will represent the aft side of the quarter-piece at the outside. Then set off the thickness of the quarter-piece, which is one foot six inches, afore the curve already drawn; and another curve being described parallel to it from the lower part to the top of the sheer, and the quarter-piece at the outside will be represented. On the horizontal line drawn for the upper part of the taff-rail set off forward the thickness of the taff-rail, which is one foot; then draw a curve down to the head of the quarter-piece parallel to the first, and that part of the taff-rail will be described. Instead of a fair curve, it is customary to form the upper part of the taff-rail with one or two breaks, and their curves inverted. Either way may, however, be used according to fancy.

Set off the depth of the taff-rail, which may be about three and a half feet, on the line drawn for the projection, from the upper part, and from this point, describe a curve as low as the heel of the quarter-piece, and about five inches abaft it at that place; observing to make it run nearly parallel to the after edge of the quarter-piece; and the after part of the quarter-piece, which comes nearest to the side, will be represented.

Set up on the line drawn for the projection of the balcony the height of the upper part of the balcony or breast rail, which is three and a half feet from the deck; set off the thickness of the rail below that, and describe the balcony, keeping it parallel to the foot space rail, and

terminating it at the line drawn for the after part of the quarter-piece nearest the side; and the whole balcony will then be represented.

The upper gallery is then to be described. In order to this, its length must be determined, which may be 11 feet. Set off this distance from the side timber forward with the sheer; and at this point draw a line parallel to the side timber, which line will represent the fore part of the gallery. Then take the distance between the upper part of the foot space rail and the upper part of the breast rail on a perpendicular, and set it off on a perpendicular from the upper part of the middle stool rail on the line drawn for the fore part of the gallery, from which to the fore part of the quarter-piece draw a straight line parallel to the rail below, which line will be the upper edge of the upper rim rail; and its thickness being set off, the lower edge may also be drawn. From the upper edge of that rail set up an extent equal to the distance between the lower rim rail and middle stool rail, and describe the upper stool rail, the after end of which will be determined by the quarter-piece, and the fore end by the line for the length of the gallery. There may be three sashes drawn between these two rails as before; and hence the upper gallery will be formed.

The upper finishing should next be drawn, the length of which may be one and a half feet less than the upper gallery. Draw a line parallel to the rake of the stem for the fore end of it, and let the upper part of the top side be the upper part of the upper rail, from which set down three inches for the thickness of the rail, and describe it. Describe also another rail of the same length and thickness as the former; and eight inches below; from the end of which a serpentine line may be drawn down to the upper stool rail, and the upper finishing will be completed.

The stem being now finished, the rudder only remains to be drawn. The breadth of the rudder at the lower part is to be determined from the proportions, and set off from the line representing the aft part of the stern post; which line also represents the fore part of the rudder. Then determine on the lower hance, letting it be no higher than is just sufficient, which may be about one foot above the load water-line, and set off its breadth at that place taken from the proportions. Then a line drawn from thence to the breadth set off at the lower part will be the aft side of the rudder below the lower hance. There may also be another hance about the height of the lower deck. The use of these breaks or hances is to reduce the breadth as it rises toward the head. The aft part may be drawn above the lower hance, the break at the lower hance being about ten inches, and the break at the upper

hance six inches.—The back may be then drawn. It is of elm, about four inches thick on the aft part. That thickness being set off, and a line drawn from the lower hance to the lower end, will represent the back. The head of the rudder should be as high as to receive a tiller above the upper deck. Therefore set off the size of the head above the upper deck, and draw a line from thence to the break of the upper hance, and the aft part of the rudder will be represented all the way up. The bearding should be drawn, by setting off the breadth of it at the keel from the fore side of the rudder, which may be nine inches. Set off also the breadth at the head of the wing-transom, which may be a foot. Then a line being drawn through these two points, from the lower part of the rudder to about a foot above the wing-transom, and the bearding will be represented. As the bearding is a very nice point, and the working of the rudder depending very much upon it, it should always be very particularly considered. It has been customary to beard the rudder to a sharp edge at the middle line, by which the main piece is reduced more than necessary. The rudder should, however, be bearded from the side of the pintles, and the fore side made to the form of the pintles.

The pintles and braces may next be drawn. In order to which, determine the place of the upper one, which must be so disposed that the straps shall come round the head of the standard, which is against the head of the stern-post on the gun-deck, and meet at the middle line. By this means there is double security both to the brace and standard. To obtain those advantages, it must therefore be placed about four inches above the wing-transom: the second must be placed just below the gun-deck so as to bolt in the middle of the deck-transom, and the rest may be spaced equally between the lower one, which may be about six inches above the upper edge of the keel. The number of them is generally seven pair upon this class of ships; but the number may be regulated by the distance between the second and upper one, making the distance between the rest nearly the same. The length of all the braces will be found by setting off the length of the lower one, which may be eight feet afore the back of the stern-post, and also the length of the third, which is four feet and a half afore the back of the stern-post; and a line drawn from the one extremity to the other will limit the intermediate ones, as will appear on the sheer-draught. The braces will seem to diminish in length very much as they go up; but when measured or viewed on the shape of the body, they will be nearly of an equal length. The length of the straps of the pintles which come upon the rudder may all be

within four inches of the aft side of the rudder; and the rudder being a flat surface, they will all appear of the proper lengths.

The half-breadth and body plans are next to be prepared. The half-breadth plan must be first drawn. Then produce the lower edge of the keel both ways, and let it also represent the middle line of the half-breadth plan. Produce all the frames downwards, and also the fore and after perpendiculars. Then from the place in the sheer plan, where the height of breadth-lines intersect the stem, square down to the middle line the fore and aft part of the rabbet and the fore part of the stem. Take from the dimensions what the stem is sided at that place, and set off half of it from the middle line in the half-breadth plan, through which draw a line parallel to the middle line through the three lines squared down, and the half-breadth of the stem will be represented in the half-breadth plan. Take the thickness of the plank of the bottom which is four inches and a half, and describe the rabbet of the stem in the half-breadth plan.

From the points of intersection of the height of breadth lines with the counter timber at the side, and with the counter timber at the middle line draw lines perpendicular to the middle line of the half-breadth plan, from which set off the half-breadth of the counter on the line first drawn; and from this point to the intersection of the line first drawn, with the middle line draw a curve, and the half breadth of the counter will be represented at the height of breadth, which will be the broadest part of the stem.

Take the main half breadth of timber dead flat from the dimensions, and lay it off from the middle line on dead flat in the half-breadth plan. Take also from the dimensions the main half breadth of every timber, and set off each from the middle line on the corresponding timbers in the half-breadth plan. Then a curve drawn from the end of the line representing the half breadth of the counter through all the points, set off on the timbers, and terminating at the aft part of stem, will be the main half-breadth line. Take from the dimensions the top-timber half-breadth line in the half-breadth plan, in the same manner as the main half-breadth line.

Take from the dimensions the half breadth of the rising, and set it off from the middle line on the corresponding timbers in the half-breadth plan, observing, where the word outside is expressed in the tables, the half breadth for that timber must be set off above or on the outside of the middle line. Then a curve drawn through these points will be the half breadth of rising in the half-breadth plan.

It will now be necessary to proceed to the body plan. Draw a

horizontal line, which is called the base line, from the right hand extremity of which erect a perpendicular. Then set off on the base line the main half breadth at dead flat, and erect another perpendicular, and from that set off the main half breadth again, and erect a third perpendicular. The first perpendicular, as already observed, is called the side line of the fore body; the second the middle line; and the third the side line of the after body.

Take from the dimensions the heights of the diagonals up the middle line, and set them from the base up the middle line in the body plan. Take also their distances from the middle line on the base, and set them off. Set off also their heights up the side lines, and draw the diagonals. Then take from the sheer plan the heights of the lower height of breadth line, and set them off upon the middle line in the body plan; through these points lines are to be drawn parallel to the base, and terminating at the side lines. In like manner proceed with the upper height of breadth line.

The rising is next to be set off on the body plan; it must, however, be first described in the sheer plan: take, therefore, the heights from the dimensions, and set them off on the corresponding timbers in the sheer plan, and a curve described through these points will be the rising line in the sheer plan. Then take from the dimensions the rising heights of a dead flat. Set it off in the body plan, and draw a horizontal line. Now take all the rising heights from the sheer plan, and set them off in the body plan from the line drawn for the rising height of dead flat, and draw horizontal lines through these points. Take from the half-breadth plan the half-breadths of the rising, and set them off from the middle line in the body plan, and the centres of the floor sweeps of the corresponding timbers will be obtained.

From the half-breadth plan, take the main half-breadth lines, and set them off from the middle line in the body plan on the corresponding lines before drawn for the lower height of breadth; and from the extremities of these lines set off towards the middle line, the lengths of the lower breadth sweeps respectively.

Take from the dimensions the distance of each frame from the middle line on the diagonals, and set them off from the middle line in their respective diagonal lines. Now these distances being set off, and the lower breadth and floor sweeps described, the shape of the frames below the breadth line may be easily drawn as follows: place one point of a compass in the distance set off for their length of the lower breadth sweep, and extend the other to the point which termi-

nates the breadth, and describe an arc of a circle downwards, which will intersect the points set off on the upper diagonal lines, letting it pass as low as convenient. Then fix one point of the compasses in the centre of the floor sweep, and extend the other to the point set off on the fourth diagonal, which is the floor head; and describe a circle to intersect as many of the points set off on the diagonals as it will. Then draw a curve from the back of the lower breadth sweep, through the points on the diagonals, to the back of the floor sweep. Describe also another curve from the back of the floor sweep through the points on the lower diagonals, and terminating at the upper part of the rabbet of the keel, and that part of the frame below the breadth will be formed. In like manner describe the other frames.

Through the extremities of the frames at the lower height of breadth, draw lines parallel to the middle line, and terminating at the upper height of breadth line, and from thence set off the upper breadth sweeps; now fix one point of the compass in the centres of the upper breadth sweeps successively, and the other point to the extremities of the frames, and describe circles upwards. Then from the sheer plan take off the heights of the top-timber lines, and set them off in the body plan, drawing horizontal lines; upon which set off the top-timber half-breadths taken from the corresponding timbers in the half-breadth plan; and by describing curves from the back of the upper breadth sweeps through the points set off on the seventh or upper diagonal; and intersecting the top-timber half-breadths, the timbers will then be formed from the keel to the top of the side. The upper end of the timbers may be determined by taking the several heights of the upper part of the top side above the top-timber line, and setting them off above the top-timber line on the corresponding timbers in the body plan. The lower parts of the timbers are ended at the rabbet of the keel as follows: with an extent of 4½ inches, the thickness of the bottom, and one leg of the compasses at the place where the line for the thickness of the keel intersects the base line; with the other leg describe an arc to intersect the keel line and the base. Then fix one point at the intersection of the arc and keel, and from the point of intersection of the keel and base describe another arc to intersect the former. Then from the intersection of these arcs draw one straight line to the intersection of the keel and base, and another to the intersection of the lower arc and the keel, and the rabbet of the keel will be described at the main frame. All the timbers in the middle part of the ship which have no rising, terminate at the intersection of the upper edge of the rabbet with the

base line; but, the lower part of the timbers, having a rising, end in the centre of the rabbet, that is, where the two circles intersect. Those timbers which are near the after end of the keel must be ended by setting off the half-breadth of the keel at the port in the half-breadth plan, and describe the tapering of the keel. Then at the corresponding timbers take off the half-breadth of the keel, set it off in the body plan, and describe the rabbet as before, letting every timber end where the two circles for its respective rabbet intersect.

To describe the side counter or stern timber, take the height of the wing transom, the lower counter, upper counter, and top-timber line at the side; from the sheer plan transfer them to the body plan, and through these points draw horizontal lines. Divide the distance between the wing transom and lower counter into three equal parts, and through the two points of division draw two horizontal lines. Draw also a horizontal line equidistant from the upper counter and the top-timber line in the sheer plan, and transfer them to the body plan.

Now, from the point of intersection of the aft side of the stern timber at the side, with the wing transom at the side in the sheer plan, draw a line perpendicular to the middle line in the half-breadth plan. Draw also perpendicular lines from the points where the upper and lower transoms touch the stern-post; from the points of intersection of the stern timber with the two horizontal lines drawn between, and from the intersection of the stern timber with the horizontal line between the upper counter and top-timber line. Then curves must be formed in the half-breadth plan for the shape of the body at each of these heights. In order to which, begin with the horizontal or level line representing the height of the wing transom in the body plan. Lay a slip of paper to that line, and mark on it the middle line and the timbers 37, 35, 33, and 29; transfer the slip to the half-breadth plan, placing the point marked on it for the middle line, exactly on the middle in the half-breadth plan, and set off the half-breadths on the corresponding timbers 37, 35, 33, and 29, and describe a curve through these points, and to intersect the perpendicular drawn from the sheer plan. In like manner proceed with the horizontal lines at the heigths of the counters, between the lower counter and wing transom, above the upper counter and top-timber line; and from the intersections of the curve drawn in the half-breadth plan, with the perpendicular lines drawn from the sheer plan, take the distances to the middle line, and set them off on the corresponding

lines in the body plan; then a curve described through the several points thus set off, will be the representative of the stern timber.

The round up of the wing transom, upper and lower counter, may be taken from the sheer draught, and set off at the middle line above their respective level lines in the body plan, by which the round-up of each may be drawn. The round aft of the wing transom may also be taken from the sheer plan, and set off at the middle line, abaft the perpendicular for the wing transom in the half-breadth plan, whence the round aft of the wing transom may be described.

The after body being now finished, it remains to form the fore body; but as the operation is nearly the same in both, a repetition is therefore unnecessary, except in those parts which require a different process.

The foremost timbers end on the stem, and consequently the method of describing the ending of them differs from that used for the timbers in the after body. Draw a line in the body-plan parallel to the middle line, at a distance equal to the half of what the stem is sided. In the sheer-plan take the height of the points of intersection of the lower part of the rabbet of the stem with the timber which is required to be ended, and set it off on the line before drawn in the body-plan. Then take the extent between the points of intersection of the timber with the lower and upper parts of the rabbet, and with one leg of the compasses at the extremity of the distance laid off in the body-plan, describe a circle, and the timbers may then pass over the back of this circle. Now, by applying a small square to the timber, and letting the back of it intersect the point set off for the lower part of the rabbet, the lower part of the rabbet and the ending of the timbers will be described.

The foremost timbers differ also very much at the head from those in the after body; for since the ship carries her breadth so far forward at the top-timber line, it therefore occasions the two foremost frames to fall out at the head beyond the breadth, whence they are called knuckle timbers. They are thus described: the height of the top timber line being set off in the body-plan, set off on it the top half-breadth taken from the half-breadth plan, and at that place draw a perpendicular; then from the sheer-plan take the height of the top of the side, and set it off on the perpendicular in the body-plan: take also the breadth of the rail at the top-timber line in the sheer-plan, and set it off below the top-timber line at the perpendicular line in the body-plan, and the straight part of the knuckle timber to be drawn will be determined. Then from the last mentioned point set off describe a curve

through the points set off for the timber down to the upper breadth, and the whole knuckle timber will be formed. It will hence be seen that those timbers forward will fall out beyond the main-breadth with a hollow, contrary to the rest of the top side, which falls within the main-breadth with a hollow.

The fore and after bodies being now formed, the water-lines must next be described in the half-breadth plan, in order to prove the fairness of the bodies. In this draught the water-lines are all represented parallel to the keel; their heights may, therefore, be taken from the sheer-plan and transferred to the body-plan, drawing horizontal lines, and the water-lines will be represented in the body-plan. In ships that draw more water abaft than before, the water-lines will not be parallel to the keel; in this case, the heights must be taken at every timber in the sheer-plan, and set off on their corresponding timbers in the body-plan; and curves being described through the several points, will represent the water-lines in the body-plan.

Take the distances from the middle line to the points where the water-lines intersect the different timbers in the body-plan, and set them off on their corresponding timbers in the half-breadth plan. From the points where the water-lines in the sheer-plan intersects the aft part of the rabbet of the stern-post draw perpendicular to the middle of the half-breadth plan, and upon these perpendiculars set off from the middle line the half-thickness of the stern-post at its corresponding water-line; which may be taken from the body-plan, by setting off the size of the post at the head and the keel, and drawing a line for the tapering of it; and where the line so drawn intersects the water-lines, that will be the half-thickness required: then take an extent in the compasses equal to the-thickness of the plank, and fix one point where the half-thickness of the post intersects the perpendicular, and with the other describe a circle, from the back of which the water-lines may pass through their respective points set off, and end at the fore part of the half-breadth plan, proceeding in the same manner as with the after part. A line drawn from the water-line to the point set off for the half-thickness of the post will represent the aft part of the rabbet of the post; and in like manner the rabbet of the stem may be represented. The water-lines being all described, it will be seen if the body is fair; and if the timbers require any alteration, it should be complied with.

The cant timbers of the after body may next be described in the half-breadth plan; in order to which the cant of the fashion-piece must be first represented. Having, therefore, the round aft of the wing-tran-

som represented in the half-breadth plan, and also the shape of a level line at the height of the wing-transom ; then set off the breadth of the wing-transom at the end, which is one foot four inches, and that will be the place where the head of the fashion-piece will come : now to determine the cant of it, the shape of the body must be considered ; and it must be canted in such a manner as to preserve as great a straightness as is possible for the shape of the timber, by which means the timber will be much stronger than if it were crooked; the cant must also be considered, in order to let the timber have as little bevelling as possible. Let, therefore, the heel of the timber be set off on the middle line, two feet afore timber 35; and then drawing a line from thence to the point set off on the level line for the wing-transom, the cant of the fashion-piece will be described, and will be found situated in the best manner possible to answer the before mentioned purposes.

The cant of the fashion-piece being represented, the cant of the other timbers may now be easily determined. Let timber 29 be the foremost cant timber in the after body, and with a pencil draw timber 28 ; then observe how many frames there are between timber 28 and the fashion-piece, which will be found to be nine, namely, 29, 30, 31, 32, 33, 34, 35, 36, and 37. Now divide the distance between the timber 28 and the fashion-piece on the middle line into ten equal parts : divide also the corresponding portion of the main half-breadth lines into the same number of equal parts ; and straight lines joining the corresponding points at the middle line, with those in the half-breadth line, will represent the cant timbers in the after body.

The line drawn for the cant of the fashion-piece represents the aft side of it, which comes to the end of the transoms ; but, in order to help the conversion with regard to the lower transoms, there may be two more fashion-pieces abaft the former ; therefore the foremost fashion-piece, or that which is already described in the half-breadth plan, may only take the ends of the three upper transoms, which are the wing, filling, and deck : the middle fashion-piece may take the four next, and the after fashion-piece the lower ones ; therefore set off in the half breadth plan the sliding of the middle and after fashion-piece, which may be 13 inches each ; then by drawing lines parallel to the foremost fashion-piece, at the aforesaid distance from each other, the middle and after fashion-piece will be represented in the half-breadth plan.

The fashion-piece and transoms yet remain to be represented in the sheer plan ; in order to which, let the number of transoms be determined, which, for so large a buttock, may be seven below the deck

transom: draw them with a pencil, beginning with the wing, the upper side of which is represented by a level line at its height; set off its siding below that, and draw a level line for the lower edge. The filling transom follows; which is merely for the purpose of filling the vacancy between the under edge of the wing and the upper part of the deck plank: it may therefore be represented by drawing two level lines for the upper and lower edge, leaving about two inches between the upper edge and lower edge of the wing transom, and four inches between the lower edge of the gun-deck plank; then the deck transom must be governed by the gun-deck, letting the under side of the gun-deck plank represent the upper side of it, and setting off its siding below that; the under edge may also be drawn: the transoms below the deck may all be sided equally, which may be eleven inches; they must also have a sufficient distance between to admit the circulation of the air to preserve them, which may be about three inches.

The transoms being now drawn with a pencil, the fashion-piece must next be described in the sheer plan, by which the length of the transoms, as they appear in that plan, will be determined. As the foremost fashion-piece reaches above the upper transom, it may therefore be first described: in order to which, draw a sufficient number of level lines in the sheer plan; or, as the water lines are level, draw therefore one line between the upper water line and the wing transom, and one above the wing transom at the intended height of the head of the fashion-piece, which may be about five feet: then take the height of these two level lines, and transfer them to the body plan; and take off two or three timbers and run them in the half-breadth plan, in the same manner as the water lines were done; then from the point where the line drawn for the cant of the fashion-piece, in the half-breadth plan, intersects the level line drawn for the head of the fashion-piece, draw up a perpendicular to the said line in the sheer plan, making a point. Again, from the intersection of the cant line, with the level line for the wing transom in the half-breadth plan, draw a perpendicular to the wing transom in the sheer plan. Also draw perpendiculars from the points where the cant line in the half-breadth plan intersects the level line below the wing transom, and also the water lines to the corresponding lines in the sheer plan; then a curve described through these points will be the representation of the foremost fashion-piece in the sheer plan. In the same manner, the middle and after fashion-pieces may be described; observing to let the middle one run up no higher than the under part of the deck transom, and the after to the under side of the fourth transom under the deck. The transoms may now

be drawn with ink, as their lengths are limited by the fashion-pieces.

Neither the head nor the foreside of the sternpost are yet described; take, therefore, from the dimensions, the breadth of the post on the keel, and set it off on the upper edge of the keel from the aft side of post. The head of the post must next be determined, which must just be high enough to admit of the helm-post transom and the tiller coming between it and the upper deck beam; the height, therefore, that is necessary, will be one foot nine inches above the wing transom. Now, draw a level line at that height, upon which set off the breadth of the sternpost at that place, taken from the dimensions, and a line drawn from thence to the point set off on the keel will be the foreside of the sternpost; observing, however, not to draw the line through the transoms, as it will only appear between them. The inner post may be drawn by setting off its thickness forward from the sternpost, and drawing a straight line as before, continuing it no higher than the under side of the wing transom.

The cant timbers in the after body being described, together with the parts dependent on them, those in the fore body may be next formed; in order to which, the foremost and aftermost cant timbers must be first determined, and also the cant of the foremost ones. The cant on the middle line may be one foot four inches afore square timber W, and on the main half breadth line one foot nine inches afore timber Y; in which situation the line may be drawn for the cant; the aftermost may be timber Q. The cant timbers may now be described in the same manner as those in the after body, namely, by spacing them equally between the cant timber & and the square timber P, both on the main half breadth and middle lines, and drawing straight lines between the corresponding points, observing to let them run out to the top-timber half-breadth line, where it comes without the main half-breadth line.

The hawse pieces must next be laid down in the half-breadth plan; the sides of which must look fore and aft with the ship upon account of the round of the bow. Take the siding of the apron, which may be about four inches more than the stem, and set off half of it from the middle line, drawing a line from the main half-breadth to the foremost cant timber, which will represent the foremost edge of the knight-head; then from that set off the siding of the knight-head, which may be one foot four inches, and draw the aft side of it. The hawse pieces may then be drawn, which are four in number, by setting off their

sidings, namely, one foot six inches parallel from the knight-head and from each other; and straight lines being drawn from the main half-breadth line to the foremost cant timber will represent them.

The hawse holes should be described in such a manner as to wound the hawse pieces as little as possible; they may, therefore, be placed so that the joint of the hawse pieces shall be in the centre of the holes, whence they will only cut half the hawse pieces. Take the dimensions of the hawse holes, which is one foot six inches, and set off the foremost one, or that next the middle line, on the joint between the first and second hawse piece; then set off the other on the joint between the third and fourth hawse piece; and small lines being drawn across the main half-breadth, at their respective places, will represent the hawse holes in the half-breadth plan.

The hawse holes should next be represented in the sheer plan. In this class of ships, they are always placed in the middle between the cheeks; therefore set off their diameter, namely, one foot six inches between the cheeks, and draw lines parallel to the cheeks for their upper and lower part. Then to determine their situation agreeably to the half-breadth plan, which is the fore and aft way, draw perpendiculars from their intersections with the main half-breadth line to the lines drawn between the cheeks, and their true situations, the fore and aft way, will be obtained; and, by describing them round or circular, according to the points set off, they will be represented as they appear in the sheer plan.

The apron may be drawn in the sheer plan, setting off its size from the stem, and letting it come so low that the scarf may be about two feet higher than the foremost end of the fore foot; by which it will give ship to the scarfs of the stem. It may run up to the head of the stem.

The cutting down should next be drawn. Take, therefore, from the tables of dimensions the different heights there expressed, and set them off from the upper edge of the keel on the corresponding timbers in the sheer plan: then a curve described through the points set off, from the inner post aft to the apron forward, will be the cutting down. Next set off from the cutting down the thickness of the timber strake, which is 8½ inches, and a curve described parallel to the former will represent the timber strake, from which the depth of the hold is always measured.

The keelson is drawn, by taking its depth from the dimensions, and setting it off above the cutting down line; and a curve described parallel to the cutting down will represent the keelson.

The cutting down line being described, the knee of the dead wood abaft timber 27, being the after floor timber, may then be represented. Set off the siding of the floor abaft it, and erect a perpendicular in the sheer plan, which will terminate the foremost end of the dead wood: then the fore and aft arm of the knee may be half the length of the whole dead wood, and the up and down arm may reach to the under part of the lower transom; and the whole knee may be placed in such a manner that the upper piece of the dead wood shall bolt over it, and be of as much substance as the knee itself; therefore, the knee must consequently be placed its whole thickness below the cutting down line representing the upper part of the dead wood.

The sheer draught, the body, and half-breadth plans are now finished, from whence the ship may be laid down in the mould loft, and also the whole frame erected.

We may now describe the inboard works of a eighty gun ship, reverting to the same plate for its illustration.

Take from the sheer draught the stem, stern post, counter timbers, and keel, and describe them on another paper; draw in also the cutting down, keelson, apron, transoms, fashion-pieces, and decks, and the upper line of the sheer all fore and aft, also the timbers and ports.

The beams come first under consideration, and should be so disposed as to come one under and one between each port, or as near as can be to answer other works of the ship; but where it happens that a beam cannot possibly be placed under the port, then a beam arm should be introduced to make good the deficiency. Every beam, and also the beam arms, should be kneed at each end with one lodging and one hanging knee; and in those parts of the ship which require the knees to be very acute, such as the after beams of the gun-deck, and in some ships, whose bodies are very sharp, the foremost beams of the gun-deck, there should be knees of iron. Care should be taken always to let the upper side of the knees be below the surface of the beams in large ships one inch and a half, and in small ships an inch, by which means the air will have a free passage between the knees and under part of the deck. In the conversion of the beams, the side next the lodging knee should be left as broad at the end of the beam as can possibly be allowed by the timber, the beam retaining its proper scantling at the end of the lodging knee: by so doing the lodging knees will be more without a square, which consequently makes them the more easy to be provided.

In ships where the beams can be got in one piece, they should be so disposed as to have every other one with the butt end the same way;

for this reason, that the butts will decay before the tops. In large ships the beams are made in two or three pieces, and are therefore allowed to be stronger than those that are in one piece. The beams in two pieces may have the scarf one-third of the length, and those in three pieces should have the middle piece half the length of the whole beam. The customary way of putting them together is to table them; and the length of the tablings should be one-half more than the depth of the beam. It is very common to divide the tablings in the middle of the beam, and that part which is taken out at the upper side to be left at the lower side, and then kersey or flannel is put into the scarf: but in this case the water is liable to lie in the scarf, and must be the means of rotting the beams. If, however, the beams were tabled together in dovetails, and taken through from side to side, putting tar only between them, which hardens the wood; then the water occasioned by the leaking of the decks would have a free passage, and the beam would dry again; and this method would not be found inferior in point of strength to the other. The length of the fore and aft arm of the lodging knee should extend to the side of the hanging knee next to it; but there is no necessity for that arm to be longer than the other. In fastening the knees, care should be taken to let one bolt pass exactly through the middle of the throat, one foot six inches from each end, and the rest divided equally between; observing always to have the holes bored square from the knee. The bolts for the thwartship arms of both hanging and lodging knees may go through the arms of each knee, and drive every one the other way.

In order to draw the beams in the draught, take the moulding of the lower deck beams, and set it off below the line representing the deck at the side, and draw a line in pencil parallel thereto, which will represent the under side of the beams. In like manner represent the under side of the beams for the upper deck, quarter-deck, forecastle, and roundhouse. Then take the siding of the lower deck beams, and place one under and one between each port, all fore and aft, drawing them in pencil. Determine the dimensions of the well fore and aft, which is ten feet, and set it off abaft the beam under the eighth port, placing the beam under the ninth port at that distance; those two beams may then be drawn in ink, and will terminate the extent of the well the fore and aft way; and as a beam cannot go across the ship at that place upon account of its being the well and mast room, there must therefore be a beam arm between these two beams.

The main hatchway should then be determined, letting the beam that forms the fore part of the well form the aft part of it, and the beam

under the next part may form the fore side of it, which beam may also be now drawn in ink: there should also be another beam arm introduced in the wake of the main hatchway.

The fore hatchway may be next determined; the fore side of which should range well up and down with the after end of the forecastle, and it may be fore and aft, about four-sevenths of the main hatchway. At the fore side of the fore hatchway there must be a ladderway down to the orlop, which may be as much fore and aft as the beams will allow. The rest of the beams afore the fore hatchway may remain as first placed, there being nothing in the way to alter the ship. Then determine on the after hatchway, the fore side of which comes to the aft side of the mainmast room.

There should also be a hatchway, the fore side of which may be formed by the aft side of the beam under the twelfth port, which is for the conveniency of the spirit and fish rooms; and there should be a ladderway abaft it to lead down to the cockpit. There may be also another hatchway, the fore side of it to be formed by the aft side of the beam under the eleventh port. The size of the ladder and hatchways must be governed by the beams, as when there is a good shift of beams they should not be altered for ladder and hatchways, unless it is the three principal hatchways, which must always be of a proper size, according to the size of the ship.

The after capstan must be placed between the two hatchways last described, and the beams abaft may stand as they are already shifted, observing only the mizenmast. There should be a small scuttle placed afore the second beam from aft, for the convenience of the bread room: it must be on one of the middle lines, as there is a carling at the middle under the four or five after beams to receive the pillars for the support thereof.

The bits may be placed, letting the fore side of the after ones come against the aft side of the beam abaft the third port, and the fore side of the foremost ones against the next beam but one forward; then at the fore side of each bit there should be drawn a small scuttle for the conveniency of handing up the powder from the magazine. The breast hook should also be drawn, which may be three feet the moulding away, and sided nine-tenths of the beams of the lower deck.

The gun-deck, beams, knees, &c. being described; in which, as well as all the decks having ports, the same precautions are to be used as in the gun-deck; and observing to keep the beams upon one deck as nearly as possible over the beams of the other, for the conveniency of pillaring, as they will then support each other.

The hatchways are to be placed exactly over those on the lower deck, each over each; and therefore, where there is a beam arm in the lower deck there must also be one above it in the upper deck, and the same in the middle deck in three-deck ships. It commonly happens in ships of the line that there cannot be a whole beam between the deck breast hook and the beam that supports the step of the bowsprit, because the bowsprit passes through that place: in this case, there must be a beam arm placed, letting the end come equally between the beam and the breast hook; but in ships that the bowsprit will allow of a whole beam, then the ports and the rest of the beams must be consulted in order to space it; and when it so happens that the foremast comes in the wake of a port, then a beam arm must be necessarily introduced.

The positions of the main-topsail-sheet bits are next to be determined; the foremost of which must be so placed as to let its fore side come against the aft side of the beam abaft the main hatchway, and to pass down to the lower deck, and there step in the beams; admitting it to be a straight piece, it would come at the aft side of the lower deck beam the same as it does at the upper deck beam, in consequence of those two beams ranging well up and down with each other: it must therefore have a cast under the upper deck beam, by which the lower part may be brought forward sufficient to stop in the lower deck beam. The aftermost must be placed against the fore side of the beam abaft the mast, and step on the beam below; but there is no necessity to provide a crooked piece as before, for the beam of the upper deck may be moved a little farther aft, till it admit of the bit stopping on the lower deck beam, unless the beam comes under a port, as in that case it must not by any means be moved. The cross pieces to the bits should be on the fore side, and in height from the upper deck about one-third of the height between it and the quarter deck. With regard to the heads of the bits, the length of the ship's waste should be considered; and if there is length enough from the forecastle to the foremost bits to admit of the spare geer being stowed thereon without reaching farther aft, the quarter deck may then run so far forward that the head of the foremost bits shall tenon in the foremost beam; this gives the mainmast another deck, and admits of the quarter deck being all that the longer: but if there is not the room before mentioned, then the quarter-deck must run no further forward than the after bits, which will then tenon in the foremost beam; and the foremost bits must have a cross piece let on their heads, which is termed a *horse*, and will be for the purpose of receiving the ends of the spare geer.

The length of the quarter-deck being now determined, the beams are

then to be placed. For this purpose the several contrivances in the quarter-deck must be previously consulted. It is necessary to observe, that there are neither carlings nor lodges, the carlings of the hatches expected, in the quarter-deck, round-house, and forecastle; as they would weaken instead of strengthening the beams, which should be as small as the size of the ship will permit, in order that the upper works may be as light as possible. Hence, as there are to be neither carlings nor lodges, the deck will require a greater number of beams, and a good round up, as on the contrary the deck would be apt to bend with its own weight. The most approved rule is therefore to have double the number of beams in the quarter-deck as there are in a space of the same length in the upper deck.

Then proceed to shift the beams to the best advantage, consulting the hatchways, ladder-ways, masts, bits, wheel, &c. With respect to the ladder-ways on the quarter-decks of all ships, there should be one near the fore part of the great cabin for the officers, and another near the foremost end of the quarter-deck, consisting of double ladders for the conveyance of the men up from the other decks in cases of emergency; and likewise one on each side of the fore part of the quarter-deck from the gangway: and in every ship of the line all the beams from the foremost ladder-way to the after one should be opened with gratings, both for the admission of air, and for the greater expedition of conveying different articles in the time of action.

The forecastle beams should be placed according as the works of the deck will admit. The hatchways are therefore to be considered first. There should be one for the funnel of the fire hearth to pass through, and one for the copper to admit of vent for the steam; and also one or two over the galley as the forecastle will admit of. The fore-topsail-sheet bits should be so disposed as to come one pair on the fore and one on the aft side of the mast, to let into the side of the forecastle beams, and step on the upper deck beams below: there should also be a ladder-way at the fore part of the forecastle for the conveniency of the fore part of the ship.

The beams may now be placed agreeably thereto, their number being four more than there are in a space in the upper deck equal in length to the forecastle; and where there happens to be a wide opening between the beams, as in the case of a hatchway, mast room, &c. then half a beam of fir may be introduced to make good the deficiency. The foremost beam should be of a breadth sufficient to take the aft side of the inboard arms of the catheads, as they are secured upon this beam by being bolted thereto. Every beam of the forecastle should be kneed at

each end with one hanging and one lodging knee: the vertical arms of the hanging knees should reach the spirketing, and the knees be well bolted and carefully clenched.

Proceed to the round-house; the same things being observed with respect to the beams as in the quarter-deck: for as the round-house beams are sided very small, it hence follows that they must be near to each other. Let therefore the number of beams on the round-house be four more than in the same length of the quarter-deck; every other beam being of fir for lightness, and every oak beam may be kneed at each end with one hanging and one lodging knee; the hanging knees abaft may be of iron, their vertical arms to be in length two-thirds of those of wood. The round-house should always have a great round up, both for strength and conveniency. There must be on the round-house a small pair of knee-bits on each side of the mizenmast, turned round and scarfed over each other, and bolted through the mast carlings. There must also be a companion on the round-house placed over the middle of the coach, in order to give light thereto.

With regard to placing the round-house beams, the uprights of the steering wheel and the mizenmast are to be observed; as when the beams which interfere with those parts are properly spaced, the rest may be disposed of at discretion, or at an equal distance from each other, and letting the beam over the screen bulkhead have a proper round aft, agreeably to the quarter-deck beam underneath.

The upper parts of the inboard works being now described, proceed next to the lower parts, or to those which come below the lower deck. Draw in the orlop, by taking the heights afore, at midships, and abaft, between that and the gun-deck, from the dimensions, and a curve described through these points will represent the upper part of the deck. Set off the thickness of the plank below, and the under side of the plank will be represented. As this deck does not run quite forward and aft as the other decks, the length of it must be therefore determined; for this purpose let the after beam be placed at a sufficient distance from aft to admit of the bread rooms being of a proper size for the ship, which will be under that beam of the gun-deck that comes at the second part from aft. The after beam being drawn in, proceed to space the other beams, placing them exactly under those of the gun-deck; and that which comes under the foremost beam of the gun-deck may terminate the fore part of the orlop. Draw the limber strake, by setting off its thickness above the cutting down line, and a line drawn parallel thereto will represent the limber strake. That

part of the orlop which is over the after magazine, spirit room, and fish room, and also that which is over the fore magazine, is laid with thicker planks than the rest of the deck; which is for the better security of those places, the planks being laid over the beams; but in the midships, from the fore part of the spirit room to the aft part of the fore magazine, the beams are laid level with the surface of the deck, and the planks are rabbeted in from one beam to the other.

In order to represent the orlop as just described, the dimensions of the different apartments above mentioned must be determined: Let the aft side of the after beam be the aft side of the after magazine, and from thence draw the bulkhead down to the limber strake; and the fore side of the third beam may be the fore side of the after magazine, drawing that bulkhead likewise, which will also form the aft side of the fish room; the fore side of the fish room may be drawn from the aft side of the fifth beam, which will also represent the aft side of the spirit room; then the fore side of the spirit room may be drawn from the fore side of the sixth beam. Hence from the fore side of the sixth beam quite aft the deck will be represented by the two lines already drawn, and the upper side of the beams will be represented by the lower line.

Proceed next to the fore part of the orlop, letting the fore side of the after bits be the aft part of the foremost magazine, drawing the bulkhead thereof, which will come to the aft side of the sixth beam; therefore, from the sixth beam to the foremost end of the orlop, the plank and beams will be represented just in the same manner as before mentioned for the after part of the orlop; then the midship part of the deck will be represented by letting the upper line be the upper side of the plank, and likewise the upper side of the beams; and the lower line will represent the lower edge of the plank, only drawing it from beam to beam, and observing not to let it pass through them.

The hatchways, &c. may now be represented on the orlop, letting the main, fore, and after hatchway, be exactly under those of the gun-deck: there must be one over the fish room, and one over the spirit room. There must be two scuttles over the after magazine for the passage to the magazine and light room. There should also be one afore the fourth beam from forward for the passage to the fore magazine, and one abaft the second beam for the passage to the light room.

The above particulars are all that our limits will permit with reference to a large vessel on the old construction, as a great portion of our future pages must be devoted to the improved state of the art.

Fig.10.

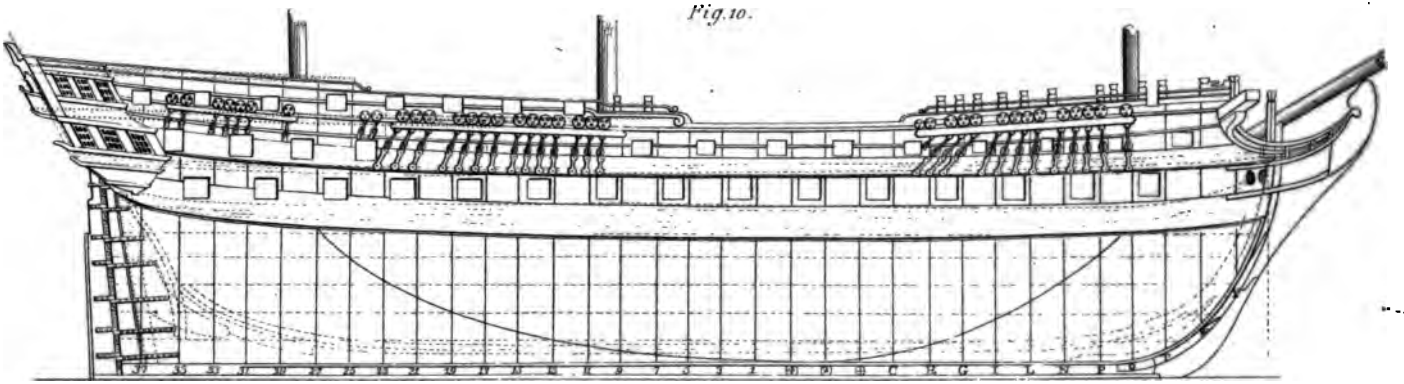
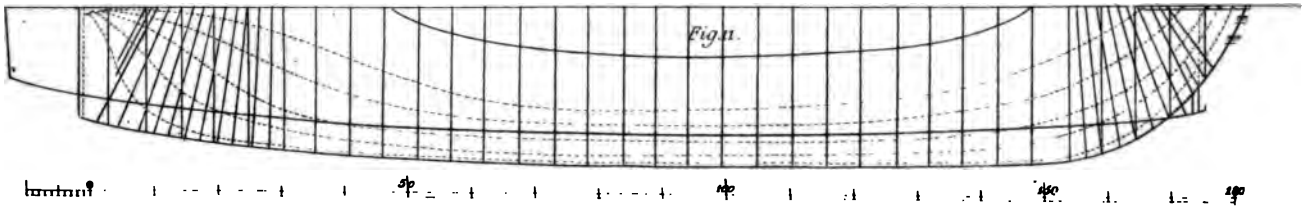


Fig.11.



Scale of feet.

C Gladwin. Sculp.

We come now to what may be considered as a new era in the art of ship building. Sir Robert Seppings, to whom we are indebted for some of the most important improvements in marine architecture, which have characterized the present century, will claim a prominent place in our pages, and the elaborate calculations by Dr. Young must form the best supplement to his ingenious labours.

Several large ships, now at sea, have already been rebuilt at Chatham on the principle about to be explained; and, from the favourable reports of those ships, the Lords of the Admiralty have given their orders for the building of several new ships upon the same principle.

To shew, in as clear a light as possible, the advantages of the application of this new principle to ship building, it may be necessary, for the information of those who are not acquainted with that art, to give the following general outline of the structure of a ship on the old principle.

1st. The frame of a 74-gun ship is formed of more than eight hundred different timbers, placed at right angles to the keel, which may be considered as the back bone of an animal, and the frame timbers its ribs. Each rib is composed of several pieces of the thickness of fourteen inches, or thereabouts. Between the several divisions of the frame, or ribs, is a space from one to five inches wide.

2dly. The whole exterior frame is covered with planks of different thicknesses, or to carry on the figure, the ribs are covered by a skin of greater or less substance from the extreme ends of them to the keel or back bone.

The inside of the frame is also almost entirely lined with planks; within which is another partial range, as it were, of interior ribs, at a considerable distance from each other, termed riders.

3dly. Across this frame are pieces of timber called beams, united together so as to be of sufficient length to reach from one side of the ship to the other.

The use of these beams is to secure the sides of the ship, so as to prevent her upper works from spreading, and to keep that part which is under water from being compressed by the fluid. They are also the supports or bearers of the decks (or what we call in houses the girders for the floors) and must therefore be of such strength as to endure the weight of the cannon, and whatever else is to be placed upon them. The usual mode of fastening these to the sides, has, generally speaking, been merely local, by two angular pieces of timber or iron (called knees) bolted to each beam, and also to the sides of the ship, by which means they were only partially held to the side, and there was wanting

that continuity of materials, and consequently of strength, which the new system gives.

Between the beams and at right angles with them are placed pieces of wood called carlings, and at right angles with these (consequently parallel to the beams) ledges, which correspond with joists in a house. The planks or flat of the deck (flooring) is laid nearly in parallel lines from head to stern, upon and at right angles with the beams, and is fastened to them and to the carlings and ledges by bolts, nails, or wooden pins, called treenails. From this statement it will appear evident, that the decks, according to the old construction, are in nowise connected with the sides of the ship.

Having thus briefly described the common mode of ship building, it will next be proper to point out such of its defects as the new principle tends to remove.

In the first place, it will be perceived, that all the materials composing the fabric of a ship are disposed nearly at right angles to each other.

This disposition which, in every wooden fabric is well known to the meanest mechanic, to be the weakest, is particularly so in a ship, the immense body of which, subject to violent action from impulses in every direction, is sustained by a greater pressure on the centre than the extremities, arising chiefly from the difference in the fore and after parts of the body, to that of the midship, or middle part.

From the want of a continued succession of support from the centre to the extremities, originates the tendency to arching, or hogging. This tendency shews itself in a ship from the moment of her launching; from whence some idea may be formed to what extent it will be carried in a troubled sea, when in the act of pitching she is borne up by the fluid only in her central part, while the head and stern are forsaken, and therefore unsupported by the water.

If a straight line be drawn from the head to the stern of a ship, whilst on the slip, or in the dock, no sooner has she entered her own element than each end of this line will be found to have dropped from two to five or six inches, in consequence of the weakness of the fabric, and the two extremes wanting the quantum of support which the fluid gives to the central part.

The length of a 74-gun ship being 170 feet or more, it requires but little knowledge of the strength of timber to perceive that planking of that length, however thick, or in whatever way joined or put together, must, under the present system, bend with its own weight. The fastenings, and consequently the connection of the several parts of the

fabric, must therefore suffer for the want of *stiffness*, and a change of form is the consequence.

This may be shewn by putting together four pieces of wood, and the securing them with iron pins in the form of a square; which on the least pressure may be made to change its form to the rhombus; but let another piece be fixed to it diagonally, and the figure of the frame will be found immoveable. Place a bar in the middle parallel, to two of the sides, and secure it firmly by iron pins, still the figure will easily be moved by the hand, like a parallel ruler, and assume the rhomboidal shape of A or B; fig. 1, 2, plate 13, but apply to the frame what the carpenters term the brace in a common field gate as Z, fig. 3, and the figure will remain, as before, immoveable.

If this brace or diagonal piece is not fixed to it, the outer part of the gate (or that part most distant from the hinges) will have a constant tendency downwards, until at length it will reach the ground.

Let fig. 4 and 5 represent two frames of wood composed of parts strongly connected by bolts or iron pins.

Fig. 4. Will represent the principle on which the present system of ship building is conducted.

Fig. 5. The new principle.

Let CC represent the fulcrum, or point of support.

And DD two weights attached for the purpose of ascertaining the comparative strength or stiffness of each frame.

This experiment will shew that the stiffness of fig. 5 is to that of fig. 4, as 6 is to 1, and the strength as 3 to 1.

The greater the length of the frames, the greater will be the advantages of the new principle, both in stiffness and strength.

The substitution of the triangle, as in the frame of fig. 2, for the rectangle in the frame fig. 1, comprehends the principle of the new system, the use and advantages of which will be sufficiently evident.

The arrangement of the materials in the triangular mode is such, that the pieces disposed horizontally are acted upon as ropes are by a strain of the fibre, whilst the other parts, composing a series of triangles, are pressed upon as pillars; in other words, the pressure acts in the direction of the fibres of the wood; whereas upon the rectangular, or old plan, the fibres are acted upon transversely, or across the grain, in the same manner as a stick is when placed across the knee and pressed by the hands at each end, which first bends, and then breaks.

To prevent any transverse action upon the fibre of the timber, is one of the benefits arising from the new system, and to impede a longitudinal extension of the structure, is another.

For as the diagonal frame, composed of a series of triangles, aided by diagonal trussing between the ports, prevents the fabric from being acted upon transversely to the fibres of the materials horizontally placed, so the wales, the planking, the shelf pieces, the improved waterways, and the decks systematically secured, become the tie beams of the structure. In a word, the system of triangles is so constructed, in conjunction with the planking of the ship, as conjointly to possess that property of a triangle already explained, viz, that its figure is as unalterable as the compression or extension of the fibre of timber will admit it to be.

The strength of the principle has hitherto been considered as applying to, or resisting an alteration of, the figure, by giving great stiffness. It is now to be taken in another point of view, that of rendering the strength of the fabric as general and united as possible. For let it be again observed, the strength of any body is but equal to that of its weakest part.

In the new system, the openings between the ribs are filled in with slips of timber nearly to the height of the orlop, or lower tier of beams; which being then calked, and paid or pitched over, makes the frame from head to stern, and within a few feet of the greatest draught of water, one compact and water tight mass of timber; so that were any of the outer planking of the bottom to be knocked off, the ship would not only still keep afloat, but would be secured from sinking. In the old system the starting of a plank would be, and often has been fatal.

The mode of filling in these openings between the frame, where the width of the space does not exceed three inches, is by driving in slices of wood cut wedge-like; two of which being driven, one from the outside, the other from within, form the parallel space of the opening, thereby bringing the parts into the closest contact. In the openings exceeding the width of three inches, the space is occupied by pieces corresponding with the openings, the fibre of such pieces being laid in the same direction as that of the frame timbers.

These fillings occasion no consumption of useful timber, as one-fourth of the produce of slab, and other offal now sold as fathom wood, would supply a sufficient quantity for the consumption of the whole navy.

The advantages obtained by filling in the openings are these. To add to the strength and durability of the fabric, to preserve the health of the crew from the effects of the impure air arising from the filth which soon collects in these openings, to render the ship less liable to leakage, as well as to facilitate the stoppage of any leak, and lastly, to

increase, as it may be said, the thickness of the bottom from four or four and a half, (the usual thickness of the plank) to about sixteen inches, thereby lessening very considerably the danger to be apprehended from getting on shore, or foundering at sea. That it tends also to the durability of the ship, will be inferred from the following positions.

1st. That the openings in the old principle are, after a ship has had any considerable length of service, choked up in many parts with an accumulation of filth.

2dly. That no free circulation of air can be obtained in these openings by any means.

3dly. That timber being either freely exposed to, or excluded from the air, is equally preserved.

4thly. That it has been found on examining the frame and plank of old ships, that those parts (now filled in), generally decay sooner than the rest, viz. from the floor-heads in the midships, and from the dead-wood forward and abaft to the height of the orlop clamps.

If the above positions be true, it will follow, that by filling in these openings, much will be added to the durability of the ship; which also will be further promoted by omitting in these parts, the inside plank, leaving thereby the surface of the frame timbers exposed to a free admission of air as often as the ship's hold is unstowed, and by the filling in, excluding the air from two of the sides of every timber.

By omitting the inside plank, much is added to the internal capacity of the ship's hold. For though the trussed frame projects from the timbers more by five inches than the thick stuff at the floor-heads, yet, as in the old system, the perpendicular riders are brought upon the thick stuff, their projection into the hold is more by eight inches than that of the new, the advantage therefore as to stowage is in favour of the diagonal frame. A tier of iron ballast will also be disposed of in this principle many inches lower, whereby an increase of stability will be given with less weight, which will favour the ship in carrying her ports out of the water, inasmuch as greater stability will be given with less ballast.

An accurate conception of the state of the ship's hold may be formed, by referring to the longitudinal section (Pl. 13. figure 6, which is termed the Jesuit's perspective, or bird's eye view) of the internal part of one side of a 74-gun ship in a complete state, with fillings in the openings between the timbers of the frames instead of the planking over them.

In this state the diagonal timbers are introduced, intersecting the

timbers of the frame at about the angle of 45 degrees, and so disposed as that the direction in the fore, is contrary to that of the after part of the ship (as may be seen in the engraving) and their distance asunder from six to seven feet or more; their upper ends abutting against the horizontal hoop or shelf piece of the gun-deck beams, and the lower ends against the limber strakes, except in the midships, where they come against two pieces of timber placed on each side of the keelson for the purpose of taking off the partial pressure of the main-mast, which always causes a sinking down of the keel, and sometimes to an alarming degree. These pieces of timber are nearly as square as the keelson, and fixed at such a distance from it, as that the main step may rest upon them. They may be of oak, or pitch pine, and as long as can be conveniently procured.

Pieces of timber are next placed in a fore and aft direction over the joints of the frame timbers at the floor and first futtock heads, their ends in close contact with, and coaked or douelled to the sides of the diagonal timbers. In this state the frame work in the hold presents various compartments, each representing the figure of a rhomboid

A truss timber is then introduced into each rhomboid with an inclination opposite to that of the diagonal timbers, thereby dividing it into two parts. The truss pieces so introduced into the rhomboid, are to the diagonal frame what the key stone is to the arch; for no weight or pressure on the fabric can alter its position in a longitudinal direction, till compression takes place at the abutments, and extension of the various ties.

This arch-like property of the diagonal frame, not only opposes an alteration of position in a longitudinal direction, but also resists external pressure on the bottom, either from grounding or any other cause, because no impression can be made in its figure in these directions, without forcing the several parts of which it is composed into a shorter space.

The connection which is kept up by means of this trussed frame firmly attached to the timbers of the ship by circular coaks and bolts, together with the shelf pieces united to the sides and to the several beams by means of the same sort of fastenings, gives such unity to the whole as to bear no comparison with that heterogeneous and badly connected mass of materials for which it is substituted.

It has hitherto been a generally received opinion, that stiffness or inflexibility in a ship is not strength, but that a yielding or bending of the fabric is an essential quality to preserve it from being destroyed by the shocks which it is destined to sustain.

Ship not Elastic.

This misconception must have arisen from an equally incorrect idea, which is, that a ship is an elastic body, because there is a considerable degree of elasticity in the materials of which it is composed. But it should be remembered, that this elasticity of the materials must be very inconsiderable, inasmuch as the minute degree of elasticity in each piece must necessarily be neutralised in the fabric, by the various directions and tendencies of the numerous parts of which it is composed, so that a ship, let her construction be what it may, either loose or firm, is not in any case elastic. It follows then, that every action and reaction of the sea operating upon different parts of the fabric at different times, occasions, for the want of unity of the whole of the parts, a constant and increasing weakness, which by some may have been taken for elasticity.

When a sea strikes a ship forward, the bow will rise with the sea; which passing aft, lifts the midships in succession, leaving at this time, in a great measure, the fore and aft parts of the ship with comparatively little, or no support. Such shocks, acting upon a body whose parts are not firmly connected, produce a bending and rebending of the fabric, so that the several planks of the sides play over each other, and the fastenings are strained and loosened by a repetition of this action and reaction. On the contrary, when a body is constructed with such general unity and fixedness of all its parts, as that if one is moved the whole must move with it, then it may be said that all the parts of the structure bear their portion of the strain.

The decks come next under consideration, the beams of which are disposed in the new system nearly as usual, except that in midships, where a ship necessarily requires the greatest security, two additional beams have been introduced.

The beams of the several decks are attached to the ship's side in the following manner.

1st. By shelf pieces or internal hoops, distinguished by the letter E. These shelf pieces are composed of several lengths of timber scarfed or joined together by coaks, or circular douels, so as to form a kind of internal hoop, extending from the hooks forward, to the transoms abaft, to the underside of which, as well as the under parts of the beams, they are securely coaked, and being then firmly bolted to the side, instead of becoming a mere local fixture of the beam to the ship's exterior frame, as knees were, they are one continued and general security. The shelf piece is also a tie to the topside in a fore and aft direction, cooperating with the trussed frame, as already explained.

2dly. By chocks, represented in the same figure at letter H., which are

placed under all the shelf pieces in wake of the beams, except the orlop, in such a manner as to receive the up and down arm of the iron knees. The lower ends of those under the gun-deck shelf piece, step on the ends of the orlop beams, and those of the several decks above, step on the projecting part of the spirketting below. The chocks, particularly those between the orlop and gun-decks, admit of their being driven into their respective places very tight, thereby acting like pillars. Another advantage attending them, is their great tendency to stiffen the ship's side, and to prevent the beam ends from playing on the fastenings when the ship is rolling, or straining under a press of sail.

The curved iron plate knees for securing the orlop beams, and the iron forked knees of the other decks, are described in the same plate.

The flat or planks of the several decks being, on the old system, each of them a mere platform, or in other words a cover to a box unconnected with the sides, are here so disposed of, as not only to oppose an alteration of figure from a force acting on the ship in a lateral direction, but also are made subservient towards securing the beams to the sides of the ship.

The framing and flat of the decks (excepting the quarter-deck, forecastle, and round-house, which are laid upon the old plan) are disposed of, as represented in the plate. The former, that is, the framing or ledges and beams in ticked lines, the latter or planks in black; those of the starboard side being laid contrarywise to the larboard. The midship ends of the diagonal planks abut against two strakes laid in a fore and aft direction without side of the comings of the hatchways; the other ends approach the timbers of the frame, and the buts at each end are secured to a tier of carlings placed for that purpose. The flat or plank of the deck so disposed is connected with a certain number of coaks to the hooks, beams, and transoms. When the decks are thus laid, waterways, as already described, are brought upon, and coaked to the ends of the plank. These waterways being then bolted through the ship's sides, and also, in an up and down direction, through the flat and shelf pieces, combine the whole in one homogeneous mass of great strength.

Few ships are without some complaint of apparent weakness after three or four years service. These defects among other places shew themselves at the beam ends, which partial complaining proceeds in a great degree from the local attachment of the beams to the ship's side, and the flat or covering being in to'o unconnected, as already explained. The extreme ends of the beams not being properly secured, play and work upon the fastenings, so that it is not unusual to see the bolt

holes cut to an oval figure by the friction of the bolts. The remedy usually applied to a ship in this state is to load her with additional materials, such as iron kness, standards, breasthooks, &c., thus adding greatly to the original weight of the fabric. Now it is evident, that the first gale of wind the ship encounters, after being thus partially strengthened, she must be reduced to the same state of weakness she was in before the remedy was applied.

This mode of strengthening ships may be compared to that of a raft firmly secured in the first place by strong lashing, which after some time works loose, or rather by working is stretched. As it might be too tedious a business to secure the raft by retightening the lashing, a small cord, or some twine, would be used to answer the purpose. It is clear that whilst the small cord or piece of twine remained tight, no part of the strain can bear upon the strong, but loose lashing, till the other stretches or breaks; so it is with a ship that has additional securities given her without refastening those which had worked, or were much strained.

To remedy defects, whether arising from the decay of the materials, or from any other cause, the principle now applied has many advantages, of which a slight inspection of the ship's hold, will convince, but in no respect is this advantage greater, than in the decks, for by shifting them when worn too thin for calking, the original connection between the beams, decks, and sides, will be restored as perfect as at first.

The tendency of the ship to stretch or draw asunder in her upper works, being by no means obviated by the short planks on the inside between the ports, a truss piece of plank is substituted in lieu of them, which being well secured at the abutments, very materially aids the trussed frame, and gives great stiffness, thereby opposing the inclination to arch or hog aloft.

On the same plate is seen a representation of the stern of a ship with the trussing and iron work for its security. By this the helm port transom, which consumes one of the largest and most difficult trees required for a ship, is dispensed with.

Those essential qualities of strength, safety, and durability, having been detailed, a few observations with respect to the economy of the new principle may not be misplaced, which though but of a secondary consideration compared to the others, yet as the royal navy cannot be kept up without a supply of foreign timber, it evidently becomes a subject of considerable moment, that upwards of one hundred and eighty oak trees should be saved in a seventy-four, and a greater number in

larger ships, allowing each tree to measure a load, or fifty feet rough contents.

The consumption of this scarce article may be further considerably lessened in the new system by the use of inferior, and old ship timber, which cannot be employed in the other, and if old ship timber was to be generally introduced, as was done in the Ramillies, one seventh part of the English oak required for a new 74-gun ship might be saved.

The facility of ascertaining the state, and making good the defects of the frame in the lower part of the ship, in consequence of omitting the inside planking, will also occasion a considerable saving of timber and workmanship, indeed the great ease by which any part of the diagonal frame may be replaced, justifies the making use of fir timber, particularly for the longitudinal piece and trusses.

But should the well grounded hopes of durability be realized, the saving of timber, and indeed of every article required for this enormous branch of the national expenditure, would be immense.

Sir Robert Seppings concludes his paper by observing, that the appointment of most excellent and meritorious officers to the ships already completed on his principle, may be considered as a most favourable circumstance towards ascertaining the real merits of the construction.

Indeed, the orders for carrying this new principle of constructing His Majesty's ships into effect, were directed by such an honourable spirit of liberality; and so unshackled was the authority given, to enable Sir Robert to carry his plans into execution, that no subterfuge could have availed him should any failure have been found in the system.

The advantage derived from the employment of forces acting obliquely with respect to each other, in a variety of cases which occur in practical mechanics, has been demonstratively established by theoretical writers on the subject; and attempts have often been made to extend the application of the principle very considerably in the art of ship building; but hitherto with very little permanent success. Sir R. Seppings's arrangements are in many respects either new or newly modified; and the results of their actual employment, in the repair of the Tremendous, appear to be sufficiently encouraging to entitle them to a careful and impartial investigation, both with regard to the theory on which they are supposed to be founded, and to the facts which may be produced in their favour. The question, respecting the best disposition of the timbers of a ship, is by no means so easily discussed, as may be supposed by those, who have considered the subject but superficially; and if we allowed ourselves to be influenced by a few hasty arguments or

experiments, we might be liable to the most dangerous errors: on the other hand, it may easily happen that objections to the application of those arguments or experiments, which may occur at first sight, may be capable of being removed by a more minute investigation: and the importance of the subject requires, that no assistance, which can be afforded by the abstract sciences, should be withheld from the service of the public, even by those who have no professional motives for devoting themselves to it.

The first consideration that is necessary, for enabling us to judge of the propriety of any arrangement respecting the construction of a ship, is to determine the nature and magnitude of the forces which are to be resisted; and the second, to inquire in what manner the materials can be arranged, so as best to sustain the strains which these forces occasion.

The principal forces, which act on a ship, are the weight of the whole fabric with its contents, the pressure of the water, the impulse of the wind, and the resistance of the ground or of a rock: and we must endeavour to ascertain the degree in which any of them have a tendency to bend the ship longitudinally or transversely, or to break through any part of her texture; and to inquire into those causes, which are likely to promote or to obviate the decay of the substances employed.

It is unnecessary to explain here the well known inequality of the distribution of the weight and pressure, which causes almost all ships to have a tendency to arch or hog, that is, to become convex upwards, in the direction of their length. It is possible that there may be cases in which a strain of a very different nature is produced: but in ships of war, this tendency appears to be universal. It is, however, very different in degree in the different parts of a ship; and of course, still more different according to the different modes of distribution of the ballast and stores, which may occur in different ships: but in ordinary cases, it will probably be found nearly such as is represented in the calculations from data which were originally furnished by an acute and experienced member of the Navy Board.

To this strain another is added, from a cause, which, although not very inconsiderable, appears, hitherto to have escaped notice; that is, the partial pressure of the water in a longitudinal direction, affecting the lower parts of the ship only, and tending to compress and shorten the keel, while it has no immediate action on the upper decks. The pressure, thus applied, must obviously occasion a curvature, if the angles made with the decks by the timbers are supposed to remain unaltered, while the keel is shortened, in the same manner as any soft and

thick substance, pressed at one edge between the fingers, will become concave at the part compressed; and this strain, upon the most probable supposition respecting the comparative strength of the upper and lower parts of the ship, must amount to more than one third as much as the mean value of the former, being equivalent to the effect of a weight of about 1000 tons, acting on a lever of one foot in length, while the strain, arising from the unequal distribution of the weight and the displacement, amounts, where it is greatest, that is, about 37 feet from the head, to 5260, in a 74-gun ship of the usual dimensions; and although the strain is considerably less than this exactly in the middle, and throughout the aftermost half of the length, it is no where converted into a tendency to "sag," or to become concave. It must however be remembered, that when arching actually takes place from the operation of these forces, it depends upon the comparative strength of the different parts of the ship and their fastenings, whether the curvature shall vary more or less from the form, which results from the supposition of a uniform resistance throughout the length. An apparent deviation may also arise from the unequal distribution of the weight through the breadth of the ship: thus the keel may actually sag, under the step of the mainmast, even when the strain, as here calculated, indicates a contrary tendency with respect to the curvature of the whole ship.

The magnitude of the strain on the different parts of a ship is subjected to very material alterations, when she is exposed to the forces of the wind and waves. The effect of the wind is generally compensated by a change of the situation of the actual water line, or line of flotation, so that its amount may be estimated from the temporary or permanent inclination of the ship; and the force of the waves may be more directly calculated from their height and breadth. These two forces can seldom be so applied, so as to combine their effects, in producing a strain of the same kind in their full extent; it will therefore be sufficient for our purpose to determine the probable amount of the force of the waves, which is more materially concerned in effecting the longitudinal curvature than that of the wind. As a fair specimen of the greatest strain that is likely to arise from this cause in any common circumstances, we may consider the case of a series of waves 20 feet in height, and 70 in breadth; the form being such, that the curvature of the surface may be nearly proportional to the elevation or depression: a single wave might indeed act more powerfully than a continued series, but such a wave can scarcely ever occur singly. We shall then find upon calculation, that the greatest strain takes place, in a 74-gun

ship, at the distance of about eighteen feet fron the midships, amounting to about 10,000 tons, at the instant when the ship is in a horizontal position; while, in more common cases, when the waves are narrower, the strain will be proportionally smaller and nearer to the extremity. Hence it appears that the strain produced by the action of the waves, may very considerably exceed in magnitude the more permanent forces derived from the ordinary distribution of the weight and pressure, being, according to this statement, nearly three times as great; so that when both strains co-operate, their sum may be equivalent to about 15,000 tons, acting on a lever of one foot, and their difference, in opposite circumstances, to about 5000. There may possibly be cases in which the pressure of the waves produces a still greater effect than this: it may also be observed, that the agitation accompanying it tends to make the fastenings give way much more readily than they would do if an equal force were applied less abruptly. At the same time it is not probable that this strain ever becomes so great as to make the former perfectly inconsiderable in comparison with it, especially if we take into account the uninterrupted continuance of its action: it appears therefore to be highly proper that the provision made for counteracting the causes of arching should be greater than for obviating the strain in the contrary direction: for example, if the pieces of timber, intended for opposing them were, on account of the nature of their fastenings, or for any other reason, more capable of resisting compression than extension, they should be so placed as to act as shores rather than as ties: although it by no means follows, from the form which the ship assumes after once breaking, that the injury has been occasioned in the first instance by the immediate causes of arching; since, when the fastenings have been loosened by a force of any kind, the ship will naturally give way to the more permanent pressure, which continues to act on her in the state of weakness thus superinduced.

The pressure of the water against the sides of a ship has also a tendency to produce a curvature in a transverse direction, which is greatly increased by the distribution of the weight, the parts near the sides being the heaviest, while the greatest vertical pressure of the water is in the neighbourhood of the keel. This pressure is often transmitted by the stanchions to the beams, so that they are forced upwards in the middle; when they are unsupported, the beams are more genorally depressed in the middle, by the weight of the load which they sustain; while the inequality of the pressure of the water co-operates with other causes in promoting the separation of the sides of

the ship from the beams of the upper decks. On the other hand, the weight of the mainmast often prevails partially over that of the sides; so that the keel is forced rather downwards than upwards in the immediate neighbourhood of the midships. The tendency to a transverse curvature is observable when a ship rests on her side, in the opening of the joints of the planks aloft, and in their becoming tighter below; although this effect depends less immediately on the absolute extension and compression of the neighbouring parts, than on the alteration of the curvature of the timbers in consequence of the pressure.

In such a case there is also an obvious strain, tending to produce a lateral curvature; and shores are sometimes employed to prevent its effects, when a ship is "hove down" on her side. This, indeed, is comparatively a rare occurrence; but when a series of large waves strikes a ship obliquely, they must often act in a similar manner with immense force: the elevation on one side may be precisely opposite to the depression on the other; and the strain from this cause can scarcely be less than the vertical strain already calculated: but its effects are less commonly observed, because we have not the same means of ascertaining the weakness which results from it, by the operation of a permanent cause. When a ship possesses a certain degree of flexibility, she may, in some measure, elude the violence of this force, by giving way a little for the short interval occupied by the passage of the wave; but it may be suspected that her sailing, in a rough sea, must be impaired by such a temporary change of form.

When a ship takes the ground, she may either give way at once to the stroke of a rock, or rest on a bottom more or less soft, until she is wholly or partially abandoned by the water. In the former case her resistance must depend, in a great measure, on the parts in the immediate neighbourhood of the injury; in the latter it may happen that she may be supported by so large a surface, as to be more in danger of parting aloft than of being crippled below. Commonly, however, the floor timbers are forced in at one end, the first futtocks, which are their immediate continuations, being broken off; and sometimes the opposite ends of the floor timbers are forced out, especially in large ships without riders, their attachment to the keel remaining unimpaired.

The causes which promote the decay of timber are only so far understood, as we are acquainted by experience with their effects. A partial exposure to moisture appears to be by far the most general of these causes: it is well known that total submersion does not

accelerate decay; a surface which is kept moist by imperfect contact with another, so that a portion of water is retained between them by capillary attraction, seems always to be the part at which the timbers begin to rot; while both the surfaces completely exposed, either to the drier air, or to the water, and those which are wedged closely together, and press strongly against each other, remain perfectly sound.

We are next to inquire into the comparative advantages of different angular positions of the timbers of a ship, for resisting the forces which have been described; and in particular how far the arrangements which have been proposed by Mr. Seppings, are better calculated for the purpose, than the common modes of construction. Whatever opinion we may ultimately form of these arrangements, they are by no means sufficiently justified by the experiments which have been exhibited in illustration of them. These experiments show, that when two parallel planks have loose pieces interposed, extending perpendicularly from one to the other, they are incomparably weaker, with respect to any transverse force, than when the intermediate pieces are in an oblique direction, so as to constitute a frame, which can only be bent as a whole. But it cannot for a moment be imagined, that the planks of a ship are connected with the timbers in as loose a manner as these transverse braces, which will scarcely support their own weight, for the purpose of the experiment; and in fact the comparison would have required that the whole space included by the parallelogram should be filled up, in each case, by similar braces, or, at least, that the two planks should have been firmly united at the loose end to the transverse braces; and it is demonstrable, that in this case the same weight would have broken the pins, as if one of the planks had been oblique, or as if the planks had remained parallel, and had been connected by oblique pieces.

Such a result would, however, be far from proving the inutility of the addition of oblique braces to a rectangular frame: for the kind of strength required for any particular purpose is not always determined by the magnitude of the force which would be capable of breaking the substances concerned, although the power of resisting such a force is properly called strength, in the most limited sense of the term: but there are many occasions on which stiffness, or inflexibility, is of material advantage. A coach spring, consisting of ten equal plates, would be rendered ten times as strong if it were united into one mass; and, at the same time, a hundred times as stiff, bending only one hundredth of an inch with the same weight that would

bend it a whole inch in its usual state, although nothing would be gained by the union, with respect to the power of resisting a very rapid motion. Now it appears to be extremely difficult to unite a number of parallel planks so firmly together, by pieces crossing them at right angles, as completely to prevent their sliding in any degree over each other; and a diagonal brace of sufficient strength, even if it did not enable the planks to bear a greater strain without giving way, might still be of advantage, in many cases, by diminishing the degree in which the whole structure would bend before it broke.

The strength of a simple rectangular frame, firmly fixed at one end, is rendered somewhat less than double, by perfectly fastening the joints at the other, and the stiffness is nearly quadruple.

The comparative security obtained by the addition of the diagonal brace, is almost without limit. Supposing any number of planks of equal dimensions to lie simply on each other without any adhesion, and to be firmly fixed at one end, their aggregate strength will be very little greater than that of a single plank of one-sixth part of the common depth or thickness of each, supported by a brace a little stronger in the direction of the diagonal of the whole; and the stiffness of the parallel planks will be as many times less than that of such a frame, as there are planks in one-third of the whole series.

Thus, if we had twelve planks, six inches deep and one thick, with friction rollers interposed, it is demonstrably true, however surprising, that they would be very little stronger in supporting a weight at the end, than a single tie an inch square in its section, assisted by a diagonal brace of equal relative strength; and also, that this apparently slight structure would be nearly four times as stiff as the twelve planks, being depressed only one-fourth as much, with a given weight, as the planks with a similar force acting on them.

It is well known, that if the planks were firmly united into one mass, their strength would be rendered twelve times as great by the union, and their stiffness 144 times.

But this is not the greatest resistance of which the materials are capable, even without any extension of their base of support; for if the planks were connected in pairs, at half the distance of the whole depth, and allowed to move freely round fastenings perfectly secure, their strength, speaking theoretically, would be greater by one-half than if they formed a compact mass, while their stiffness would be only about one-fourth as great: and an effect nearly similar might be produced, if the respective pairs were united by oblique braces, extending over half the depth of the whole

structure, although it would be very difficult, in practice, to make the strength of an arrangement of this kind even equal to that of a compact mass, since the fastenings could never be so perfect as to bring every fibre of each plank into its full action at once, as the theory supposes. If the planks were already united into a compact mass, so as to be incapable of bending, except as a whole, it is of importance to inquire, whether any advantage would be gained by the further addition of oblique braces: and it will appear, that if the braces were fixed to the outermost planks of the series only, they would have no manner of effect, either on the strength or on the stiffness, whatever might be their direction; but if they were sufficiently fastened throughout the extent to each plank with which they come into contact, they would add both to the strength and to the stiffness, very nearly in the same degree as if they were fixed in the direction of the planks, at a distance from each other equal to their shortest actual distance, so as to constitute as many ribs as there are braces in a transverse line. Hence, although there is obviously no economy in such an employment of oblique braces, yet it is by no means true that oblique braces are incapable of adding to the strength of a structure composed of pieces arranged at right angles; the assertion might, however, be very nearly correct in circumstances approaching to those of one of the experiments which have been exhibited for the purpose of illustrating the utility of such braces. On the other hand, the advantage of employing oblique braces must depend, in a great measure, on the degree in which the angular position of the structure would be susceptible of variation without them; since, when properly fastened, they must universally tend to preserve the form unaltered; although they are somewhat less calculated to add to the ultimate strength of the principal tie or shore, than if their direction had been longitudinal. To take, for example, the case of a ship's arching, or hogging: if the strength were overcome without any deficiency of stiffness, the upper decks and wales would be elongated, and the butts of the planks aloft parted; while the keel would be somewhat shortened, and the planks near it crippled, so that a ship of 176 feet long and 40 feet deep, arching one foot with a uniform curvature, would have the length of the parts aloft, on the level of the quarter-deck, 22 inches greater than that of the keel. If, on the contrary, the strength were not overcome, but the stiffness only failed, the angular situation of the parts being altered, and the joints simply becoming loose without parting the planks would slide on each other,

and their square ends would no longer remain in the same vertical line at the ports, while there would be no material alteration in the comparative length of the decks and keel, nor any permanent parting of the butts of the planks.

This comparison, therefore, brings the question respecting the general utility of oblique riders into a very narrow compass; and we have only to inquire in what way it is most usual for ships to exhibit symptoms of weakness, in order to decide it. Now it will appear that in cases of arching in general, some of the butts of the planks are always found to have parted aloft, at the same time that the angular position of some parts of the structure has as uniformly been more or less altered; and very generally a certain degree of sliding is observable in the planks, at the sides of some of the ports. This sliding is seen very distinctly in the planks of the Albion, and of the Belliqueux: at the same time there are also obvious indications of a certain degree of extension and compression. In the Albion the butts of the planks have parted so far, that, in some instances, pieces have been let in between them. And in the Belliqueux there is a space of about five inches between the middle of the deck transom and the carling, which had originally been in contact with it. In the Asia, lately launched in the Medway, the arching amounted to three inches and a quarter, and the comparative length of the upper and lower parts was probably altered about two inches at most: the parting of the butts amounting to $\frac{1}{8}$ of an inch each "for upwards of fifty feet in length in the midships, and for about eight feet from the top of the side," making a total extension of probably less than an inch: so that about half the effect seems to have been produced in one way, and half in the other; but, apparently, the greater half by the want of stiffness. It is also usually observable, that there has been some degree of permanent compression or crippling below, the butts of the planks opening when the cause of arching has been removed, and the sheathing being more wrinkled than would have happened from the simple bending of the planks. Where it has been observed that the fore part of all the treenails supported the pressure of the planks in the after part of the ship, and the after part in the fore part of the ship, the observation must probably have been made on the lower parts of the ship, from the effect of a partial compression of this kind.

From this statement it appears, that unless some very strong facts can be produced to disprove the probability, that the relative angular position of the parts constituting a ship may always be materially

altered, without an absolute failure of strength, it cannot be denied that the principle of oblique bracing offers a remedy for the tendency to arch, whatever doubts there may be of the efficacy of any particular mode of applying it. And even if no observations could be produced, in confirmation of the frequent occurrence of such a change of the angular situation of the timbers, the supposition that the stiffness could be perfect in this respect, notwithstanding the unequal shrinking of the timbers and other similar circumstances, while the ultimate strength gave way by the failure of the fastenings, is in itself so highly improbable, that no positive evidence would be required for its complete rejection. We shall find accordingly that M. Bouguer takes for granted the existence of a partial flexure, as sufficiently admissible without direct proof, and recommends the adoption of oblique planking as a remedy; and that other experienced authors have been equally favourable to the employment of some similar arrangements. In speaking of M. Gobert's mode of placing the cieling of a ship obliquely, M. Bouguer observes, that "this method cannot fail of producing the most desirable effects; for when the planking, both within and without, was arranged in the direction of the keel, it happened, in case of the ship's arching, that the rectangles formed by the timbers and the planking, merely changed their figure a little, so as to become rhomboids, two of the angles opening a little, while the other two became more acute: but when the planks of the cieling are laid in an oblique direction, they serve as diagonals to the rectangles, so that a simple change of the relative angular situations of the sides is not sufficient to admit of the arching, without an alteration of the length of the diagonals, which would afford a resistance incomparably greater, especially at the upright parts of the sides, although at the floors it would have but little effect." Traité du navire, M. Groignard also, although he objects to M. Gobert's method, confesses that he "should have very much approved this mode of disposing the cieling, if it had been possible to employ straight planks, having the same obliquity, without interruption throughout the whole of the ship's length;" but thinks, with Bouguer, that in carpentry, "every interruption is to be avoided as dangerous:" an objection so vague as neither to require nor to admit a very distinct reply. Don George Juan too, after a calculation of the absolute strength of the pieces of timber employed in the construction of a ship, very properly remarks, that the effect of arching must be attributed not to their want of strength, but to "their play upon each other."

It appears, therefore, to be sufficiently established, that the princi-

ple of employing oblique timbers is a good one, provided that it be so applied as to produce no practical inconvenience. We must next inquire, whether Mr. Seppings has introduced it in a manner likely to be effectual, and not liable to any material objections. He places on the sides of a 74-gun ship several series of oblique braces, principally between the ports, in the place of the internal planking, making an angle of about twenty-four degrees with the decks, consisting of planks four inches thick and about eleven wide, coaked and bolted to the timbers, and abutting against upright pieces similarly fastened. Now it follows, from what has already been stated, that these pieces have about four-fifths as much effect in co-operating with the neighbouring parts, which act horizontally, as if they had been placed in the same situation with them, even on the supposition that the relative angular situation of the pieces is unalterably fixed; but, for preventing the alteration of this situation, there is no doubt of their being very advantageously arranged, so far as their strength is sufficient; and the existence of a tendency to such an alteration, in a very material degree, appears to be altogether indisputable. Below the gun-deck, the oblique timbers are considerably stronger, although they act under circumstances somewhat less favourable.

If, however, the resistance of a part of a structure is very immediately directed against a certain force, without an adequate co-operation from other parts of that structure, and if, being abandoned by those parts, it is exposed to a strain which it is too weak to withstand, it is obvious that it must inevitably be the first to give way, and must leave the rest of the fabric more exposed to be overpowered by such a force, than before its introduction. We must therefore inquire, how far it is possible that Mr. Seppings's braces should be so abandoned. Now, supposing a 74-gun ship to arch two feet, and one half of the change to depend on the sliding of the planks over each other, which will be allowed, by those who doubt the utility of the arrangement, to be fully as much as can ever happen; the greatest fall of the surface will be one foot in 44, and the length of the brace will be diminished $\frac{1}{11}$, or $\frac{1}{16}$ of an inch in the length of six feet; which, with a moderate allowance for the partial yielding of the fastenings, it will be perfectly capable of supporting without being crippled, although, indeed, it could scarcely support much more. It is obvious, however, that this supposition, in many respects, far exceeds the utmost that can possibly happen: and it would even require a greater force to produce such an effect on the braces, than any which the ship actually sustains. In order to calculate the magnitude of the

greatest strain which these pieces could support, it will be safest to proceed on the supposition that each square inch of the section of good oak timber is capable of resisting the pressure of four tons on an average; it will then appear, that a single series of such braces as Mr. Seppings employs, extending throughout the length of each side of the ship, would support a weight of 143 tons, in whatever way the force counteracting it might be applied; and estimating the effect of all the braces and riders as equivalent to about four such series, the whole would resist a force of 570 tons: while the greatest force derived from the distribution of the weight, together with the action of such waves as we have considered, amounts to about 450 tons; so that the strength of these braces can scarcely be insufficient to support the pressure, unless the ship should be left dry, resting on the middle of her keel, and the braces should be abandoned by all the other parts which usually co-operate with them. The fastenings must indeed be considerably weaker than this, and the other parts of the ship considerably stronger; but since the fastenings appear to possess sufficient strength to resist any strain which is actually likely to affect them, there seems to be no inconvenience in their inferiority to the other parts. In fact, the Tremendous actually supported for three days, without any perceptible change of form, a strain fully equal to that which is here calculated, having been purposely left on shores, which extended through fifty-two feet only of her length. But it must be remembered, that such a force, from its very gradual application, must be much less trying to the ship's strength than the more abrupt changes which occur at sea; and it must, on the whole, be inferred, that it would be unsafe to trust to the braces alone, unsupported by the co-operation of the neighbouring parts. It would probably be easy to add some further strength to these braces near the ends of the ship, where the strain on them is the greatest, especially about thirty feet from the head, if it were found that they gave way before the rest of the timbers; and it might also be possible to replace them, if they had once failed, with greater ease than many other parts of the fabric.

It may be questioned how far it is allowable to omit any part of the inner planks between the ports, for which the braces are a substitute, on account of their utility in securing the butts of the planks, which are always made to shift where they are supported by this subsidiary tie: but with the outer planking which remains, and with the partial assistance of the braces, to say nothing of that of the shelf pieces, it can hardly be believed, that the tie is more likely to

part between two ports of the same deck, than immediately over one of them.

It has been very ingeniously observed, that arching is not only a part of the evil occasioned by a ship's weakness, but that it has an immediate tendency to afford a partial remedy for the cause which produces it, by making the displacement greater at the extremities of the vessel, and smaller in the middle: but, in fact, this change appears to be too inconsiderable in its extent to produce any material benefit: the strain at the midships being diminished by each inch of arching only sixty-six tons, supposed to act at one foot; so that very little relief is obtained from the change, in comparison with the whole strain.

The case of the Kent, which broke in a remarkable degree, notwithstanding the employment of riders of large dimensions, is perfectly reconcileable with the principles which have been laid down: indeed, these riders, which made an angle of a few degrees only with a vertical line, could have so little effect either on the strength or on the stiffness of the structure, that there was not the slightest reason to expect any material advantage from their application.

The explanation which has been given of the universal tendency of ships of war, in all common circumstances, to arch throughout their length, is sufficient to justify the different directions in which Mr. Seppings now arranges his braces in the different parts of the ship, since they must necessarily afford a greater strength as shores, than as ties, and since the most permanent and the greatest strain will generally be such as to call them into action in this capacity. When, however, a ship is compared to an inverted bridge, it must not be forgotten how necessary it frequently becomes, to consider these braces in a different capacity; and to provide for this contingency, as, indeed, Mr. Seppings has not neglected to do, by employing such fastenings as are extremely well adapted to secure their action as ties.

The shelf pieces which Mr. Seppings employs, and the superior strength of the fastenings of his decks to the breast hooks and transoms, have so obvious a tendency to counteract the causes of arching, that it is unnecessary to insist on their utility: the weight and expense of the shelf pieces are probably the only drawbacks upon the advantages, which they are so manifestly calculated to afford, in resisting both a vertical and a lateral strain; and even in these respects they appear to be preferable to the wooden knees formerly employed.

The filling up the intervals of the timbers throughout the hold with wedges of old stuff, is perhaps the most indisputably beneficial of all the alterations which Mr. Seppings has either introduced or revived

in an improved form. The strength which is thus obtained acts immediately in the prevention of arching, and is probably, in this respect, more than an equivalent to that of the internal planking, which has been omitted; while the cohesive strength of the external planking, considered as a tie, is still probably more than sufficient for resisting the smaller force, which occasionally operates in a contrary direction: although the strength of the ship, for resisting such a force, is certainly much diminished by the change. From the manner in which these wedges are driven by Mr. Seppings, it may easily be understood, that they may tend to produce a convexity below, without raising any part of the keel from the blocks, merely causing it to press more strongly on them at the midships; so that if this difference becomes equal to that of the weight and pressure after launching or floating, there may be no tendency to any further change whatever; and hence it may happen, that without any other superiority of stiffness, or even of workmanship, a ship may appear wholly exempt from arching, as the Tremendous did, and some other ships are said to have done. Without the operation of some such cause, even a hollow cylinder of compact oak, 180 feet long, 50 feet in diameter, and six inches in thickness, (if such a mass could be supposed to exist) would exhibit when immersed to the depth of its axis, a degree of arching just perceptible, from the longitudinal pressure of the water only, amounting to about $\frac{1}{18}$ of an inch; besides a curvature proportionably greater from the other strains, which have been already calculated. Mr. Seppings has also very properly introduced in the Tremendous an additional kelson on each side of the step of the mainmast, in order to support its weight, and to prevent the partial sagging of the keel.

With respect to the transverse strain, or the tendency of the sides to sink in comparison with the keel, some strength is probably gained by Mr. Seppings's mode of fixing the filling timbers in the same manner as the frames: and some advantage must be attributed to the co-operation of the wedges, or fillings in, with the timbers, as far as their connexion is capable of bringing them into action. The common ceiling is by no means advantageously placed for assisting in a resistance of this kind, since it can only act where the curvature would be increased by the bending of the sides, and even there can only be compressed in a transverse direction. The riders commonly placed upon it, on the contrary, are very favourably situated for assisting in this action; but Mr. Seppings's riders are so much more numerous as to possess, notwithstanding their obliquity, a still greater

force. The fastenings of the beams to the sides are also concerned in resisting a strain of this kind, as well as in counteracting the tendency to an extension aloft, which is the more immediate consequence of the unequal pressure of the water against the ship's sides. Mr. Seppings's fastenings, so far as they depend on the shelf pieces, have probably some advantage over the more common ones; but the iron knees which he employs do not appear to be quite so economically arranged as the straps of a simpler form, which other builders have used; they afford, indeed, a very direct connexion with the timbers, and they save some valuable wood in the chocks which support them: but still there appears to be some waste of strength when they act as ties, from the great obliquity of the shoulders, with respect to the direction of the force, to say nothing of the expense of the workmanship: and if, as Captain Campbell seems to have suspected, there is any slight deficiency in the transverse strength of the Tremendous at the waterways, the circumstance may afford a further reason for doubting of the utility of these fastenings.

The least obvious advantage attributable to the obliquity introduced by Mr. Seppings, appears to be in his mode of laying the planks of the decks; parts which seem to be principally required to co-operate with the sides of the ship, as ties in a longitudinal direction; for the slight curvature which is given to them can no more render them incapable of such an action, than the bending of a towing rope prevents its pulling along a boat. But, in the first place, the lower decks can have little or no action of this kind, from their near approach to the line, at which extension ceases and compression begins, at least until some of the fastenings give way; and, secondly, the upper decks lose but one third of their strength in this capacity, by having their planks disposed at an angle of forty-five degrees with the sides, while the obliquity must be capable of affording some additional power of resisting the violent action of the waves, which sometimes produces an immense strain in a transverse or lateral direction, as well as of enabling the ship, in case of necessity, to be more safely "hove down" on her side. There seems also to be some convenience in having the ends of the planks covered by the waterways, with respect to keeping the wings of the ship dry, although it has been suspected that the ends so covered may be rendered somewhat more liable to decay. It may, however, be apprehended, that any force, tending to shorten the deck, will have some little effect in forcing out the sides: for instance, if the whole deck became three inches shorter, the length of the planks remaining the same, they must force out each of the sides

about a quarter of an inch, provided that their connexion with the beams allowed such a change, which appears indeed somewhat improbable. There may possibly be a slight difficulty in adjusting the planks to the curvature of the beams; but this difficulty appears to be readily overcome in other cases, as in that of the common cieling. It may hereafter deserve to be inquired, how far an oblique direction of the carlings between the beams, which in their present situation seem to contribute very little to the strength, might enable them to co-operate in resisting a lateral force, if the arrangement could be made without too much weakening the beams, in procuring proper abutments for these pieces.

It cannot easily be admitted, that Mr. Seppings's construction affords any additional strength to a ship's bottom in case of her grounding. The fillings in between the timbers must indeed be extremely useful in this respect, first by giving firmness in the direction of the length, since even a straight plank is strengthened by having the incompressibility of its outside increased, much more one that is curved, in however slight a degree; and, secondly, by co-operating with the timbers, considered as shores, so far as the wedges are fixed in their places by their lateral adhesion or otherwise.

The cieling, which has been omitted, can have very little effect by its own strength in preventing the separation of the timbers at the floor heads; but where there are tranverse riders, it must be of essential advantage in enabling these to come into action, for the support of the neighbouring parts exposed to pressure; somewhat more effectually indeed, in many cases, than Mr. Seppings's diagonal riders and their trusses can do, notwithstanding the superiority of their number and aggregate strength, on account of the magnitude of the intervening spaces, which might happen to receive the principal stroke near their centres. This magnitude does not, however, contribute by any means in the same proportion to the weakness of the parts, as it would do if the surface were plane; and it is not improbable, that for supporting the weight of the ship on a very soft ground, Mr. Seppings's arrangement might afford equal strength with the common form, as seems to have been exemplified by his experiment of leaving the Tremendous for three days on fourteen shores only without injury: but for encountering the stroke of a rock, or of very hard ground, Mr. Seppings's ship would probably be inferior, since, in this case, greater stiffness, even with equal strength, would be detrimental rather than beneficial; while, on the other hand, she would undeniably be less liable to suffer from any injury that might happen to her outer

planking only; and, from her superiority in this respect, might possibly sustain, without inconvenience, a stroke which would be ultimately fatal to a ship of a different construction.

There does not seem to be the slightest ground for the apprehension, that the filling in should render the ship's timbers liable to decay; on the contrary, the timbers of the Sandwich were found perfectly sound in the lower half of their length, opposite to the wedges which had been driven in between them, and completely decayed in the upper half, where they had been exposed, in the usual manner, to the action of the confined moist air and water; and this result is perfectly conformable to analogy with the few facts that have been ascertained respecting the general causes of decay. The utility of the filling in, for preventing the accumulation of filth, and for keeping the ship free from foul air, with respect to the comfort, and perhaps to the health, of the crew, is too obvious to require discussion. How far the economy of timber may in all cases be so great as Mr. Seppings is disposed to believe, can best be ascertained by those who are in the habit of estimating its value: but if the durability of the vessel only were improved, at an equal expense, the adoption of his alterations would still be highly advisable.

Having thus, with the assistance of Dr. Young, fully elucidated Sir Robert Seppings' mode of constructing large vessels, we should be wanting in justice to this improver of our navy did we omit to notice his admirable paper "on a new principle of constructing ships in the mercantile service."

And first, as to the principle on which mercantile ships are at present built, and particularly as regards the putting together their ribs or frames, and the arrangement of the materials. In forming the frames or ribs, half of the timbers only are united so as to constitute any part of an arch; every alternate couple only being connected together: the intermediate two timbers (termed fillings) being unconnected with each other, and merely resting upon the outer planking, instead of giving support to it. Now, it must be very evident that ships so constructed, can by no means possess equal strength with those that have the whole of their timbers formed into frames or arches.

This loose practice is, peculiar to the English merchantship-builder; and indeed was pursued till very lately even in His Majesty's Navy, while the preferable system of connecting the ribs was common to other maritime powers.

The principle of uniting the frames, lately introduced in the construction of English ships of war, might, no doubt, be also introduced

into the mercantile navy; which would give to the ships in that employ additional strength and increased durability, without adding to the expense of building.

But the present mode of joining together the several pieces of the same rib, is also highly objectionable. It is done by the introduction of a third piece, technically termed a *chock* or *wedge piece*, of which pieces the number amounts to upwards of 450 in a 74 gun ship, and not less than that number in an Indiaman of 1200 tons: (to which class of ships the engravings furnished by Sir Robert have reference.) Of these chocks not one in a hundred is ever replaced in the general repair of a ship; for they are not only found defective, but very generally to have communicated their own decay to the timbers to which they are attached. Besides this, the grain of the rib-pieces being much cut, to give them the curvature required, has a considerable share in weakening the general fabric. That they occasion a great consumption of materials is obvious; as the ends of the two rib-pieces must first be cut away, and then be replaced by the chock.

This mode of putting together the frame, is also peculiar to the English ship-builder; and Sir Robert says, I find, from an old work in my possession, dedicated to George the First, that the practice was introduced in the construction of English ships about the year 1714: and having heard that so unfriendly to it was the builder (Mr. Naish) of the Royal William, that he refused to adopt it; and being desirous of ascertaining the fact, when that ship was taken to pieces at Portsmouth, in 1813, I found that she was built without the wedge pieces or chocks, to which, in a certain degree, I ascribe her strength and durability; her ribs being by her structure less grain-cut, and for want of chocks, less liable to decay in those parts where they are inserted.

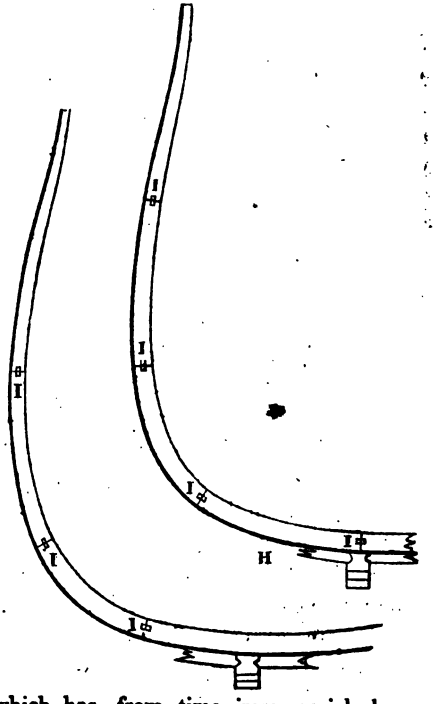
Another great defect arising out of the present plan of constructing mercantile ships is, that the ends of the lower ribs or timbers, commonly termed the lower futtocks, are not continued across the keel, so that no support is given in a transverse direction when the ship touches the ground; nor any aid to counteract the constant pressure of the mast. This great sacrifice of *strength* and *safety* is made for no other purpose than that of giving a passage for the water to the pumps.

The floor timbers, which by this mode of construction are the only timbers that cross the keel, are also weakened for the same purpose. This mode also makes the conveyance of the water very uncertain, for the passage is not unfrequently choaked; and the pumps (from its not being practicable to continue them sufficiently down) always leave from 6 to 8 inches of water in the ship; so that these compartments

constantly contain a certain quantity of putrid bilge water, offensive and injurious to the health of those on board.

The deficiency of strength causes also an alarming insecurity in the plank of the bottom, as shown at that part termed the garboard strake; which consequently, has no other fastening to the general fabric, than its connection with the keel as shewn in a previous figure: hence it is obvious, that in the event of the keel being disturbed, the garboard strake, from its being attached to it, must share the same fate as the keel, and in that case the loss of the vessel would be inevitable.

To obviate these serious defects, is Sir Robert's principal object.



The principle he would recommend is explained in the accompanying figure; by which it will be seen, that the component parts of each rib are of shorter lengths and less curvature, and consequently less graincut; that they are more firm and solid by the substitution of coaks or douels, for chocks or wedge-pieces; and that the mode of connecting the lower timbers is better adapted, in the event of a ship grounding, to give support and strength to the fabric, as will appear by the line marked H.

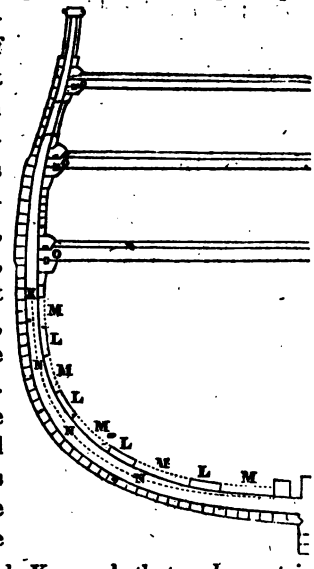
The plan of connecting the ends of the timbers by circular douels, or coaks, (as at I,) is simply that which has, from time immemorial, been practised to unite the fellies of carriage wheels; and we learn from Mr. Wood, that the same method has been observed in joining together the separate pieces of the shafts of the stone columns in the ruins of Balbec. "Little more of this great edifice (says this author) remains, than nine lofty columns supporting their entablature. It is remarkable, that the shaft of these columns consists of three pieces most exactly joined together without cement, which is used in no part of the

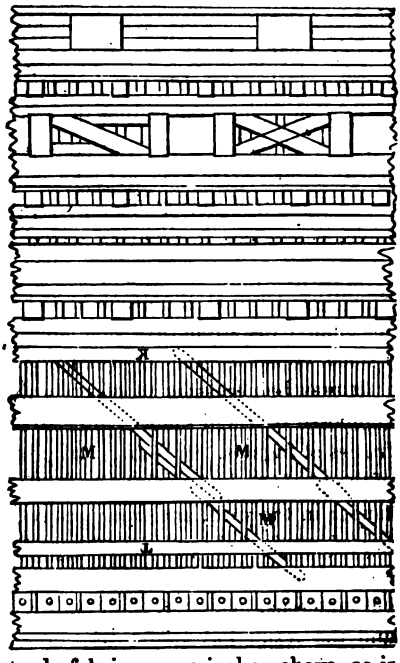
Use of Dowels.

buildings, they being strengthened *with iron pins received into a socket.* How much this method contributed to the strength of the building, is remarkably seen in the most entire temple, where a column has fallen against the wall of the cell with such violence, as to beat in the stone it fell against, and break part of the shaft, *while the joinings of the same shafts have not been in the least opened by the shock.*"

That the frame of the Thunderer, (now Talavera) built on this principle, is superior in point of strength, to a frame constructed on the common system, is fully established by a report from the officers of His Majesty's Yard at Woolwich to the Navy Board, who directed them to compare the strength of the frames so united, with those of the Black Prince, constructed in the usual way with chocks or wedges.

It may be necessary to observe, that the frame of the Thunderer is composed of small timber, hitherto considered applicable only for the frames of frigates. Sir Robert was prompted to attempt the introduction of the plan on which she is built, from there being a surplus store of small timber in the yard, and from a conviction, that a well combined number of small timbers, might be made equal, if not superior, both in strength and economy, to the large, overgrown, and frequently grain-cut materials, made use of in constructing the frames of large ships; and the result has shown the correctness of the principle; the adoption of which cannot fail to prove of great national advantage, in the application of sloop timber to the building of frigates, and of frigate timber to ships of the line, whenever larger timber cannot be procured. On this principle also, may frigates and small ships of war, or merchant vessels, be built of straight fir, without the assistance of oak or elm, which were formerly employed to give the necessary curvature of the sides. As it respects the general safety of the ship, it will be seen by the annexed and following engravings, that the timbers uniformly cross the keel; that the frame of the ship is filled so as to form one compact body to the height marked K; and that only certain internal streaks of plank, or thick stuff, as it is termed, are introduced, which are those on the joints of the timbers, for the purpose of giving





strength where every alternate timber necessarily joins, as shown at L. All the rest of the inner planking may be omitted; and dunnage battens, brought in a perpendicular direction, upon the timbers *between* the plank, as shown at M, forming regular spaces between each, as is usual at present *upon* the plank; thereby giving an increase of stowage, in proportion to the thickness of the plank omitted. Water courses, as shown by dotted lines at N, are to be left in the joints of the timber under the plank, for the purpose of conveying the water to the pumps; which, by this plan will reach below the water, instead of being some inches above, as is the case with the present mode, before described; consequently, by the proposed system, no stagnant water will remain; and farther, the limber passage, or water course, will be one smooth, uniform channel, which can be cleared with ease, should it be required, whenever the hold is unstowed; whereas at present it is inaccessible in places, and forms compartments for putrid water, without there being any means of removing it.

It is obvious, that a ship on the principle I have here recommended, may sustain the loss of certain planks of the bottom, and also the keel, (which has frequently been found to have happened to ships of war on their being taken into dock) and still reach the place of her destination; when the loss of *either*, would be the destruction of a ship built on the present mode. It will be evident also, that a ship constructed as now recommended, possesses greater stowage, and more space for leakage, than by the old plan; by the omission of the useless inner planking, and by laying the kentlage on dunnage, leaving a space for the water, which was formerly occupied by the inner lining. This dunnage in the bilge may be formed with the iron kentlage, and thereby serve as ballast, for which it is well calculated from its situation; and by its occupying a

Improvement in Stowage.

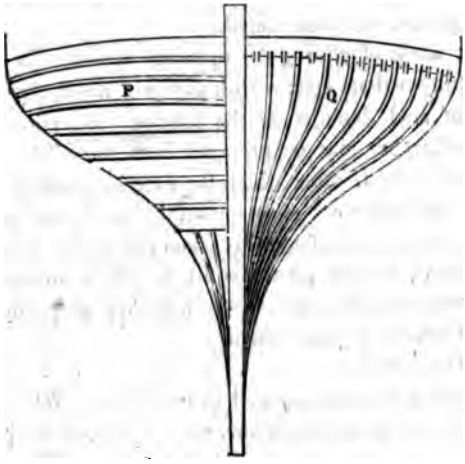
space heretofore forming part of the fabric of the ship, will give an increase of stowage, as before stated.

The best mode of closing the openings between the timbers, is by filling the intermediate spaces with pieces of wood, about three inches in depth, of such lengths as the inferior conversions will supply, abundance of which may be procured from the offal. These fillings are to be well calked, after which the exterior plank is to be brought on. When the works are going on within board, similar pieces are to be fitted internally, and afterwards taken out for the purpose of filling the spaces between the pieces so fitted, with a mixture of Parker's Roman cement and drift sand, in the following proportions, viz.

Parker's Roman cement . . . . . ½
Drift sand . . . . . ½

previously paying the opening well with coal tar. Where there is sufficient space, a brick, or part of one, may be introduced, provided there is room for cement between it and the timbers. When filled in to within about two inches of the surface of the frame, the pieces of three inches already fitted and taken out, are to be well driven in and calked, and by so doing, no space will be left unoccupied. If considered desirable, these pieces may be driven below the surface of the timber, thereby leaving water courses to convey the leakage to the pumps in channels. And prior to launching or undocking of ships, built on the principle I have recommended, it has been the practice to inject the part filled in with mineral tar, by means of a simple forcing pump, boring holes in the joints of the timbers for the introduction of the pipe. By following this method, the air will be excluded, which, as experience has shown, tends much to the durability of the fabric; confirming the assertions made by Doctor Hales on this subject, in his work on Ventilators, published in 1750, and also of Doctor Henry, in his work on the Elements of Chemistry. If what is here recommended be attended to, and mercantile ships were built under roofs, as ships of war now are, durability would be obtained in addition to safety, from the mode of their construction.

The beams are to be attached to the sides, as shown at O, in the following figure, rendering wood knees unnecesary, and requiring only a small number of those of iron.



The mark P describes the old principle of framing the stern with transoms. Q, the new principle, with timbers similar to the bow, omitting the transoms below the wing or upper transom; and by introducing the new principle on which the floors are made, the necessity of using valuable compass, or crooked timber, hitherto required, and with difficulty procured for these purposes, is avoided. Uniform support will thus be given, and also an increase of room for stowage.

In large mercantile ships above 500 tons, Sir Robert recommends that plate-iron be laid diagonally.

The principle now recommended will cause a decrease in the consumption of materials, and the difficulty of procuring the necessary curvature will be obviated. It also affords protection from worms externally, and vermin internally. Leaks may be more easily discovered and stopped than by the old method; and in point of additional strength, there can be no doubt. But were farther proof required, the inventor goes on to state, that the Malabar, of 74 guns, built at Bombay, arrived at Portsmouth in October last, loaded to her upper deck with timber; and during her passage encountered four heavy gales of wind, without showing a symptom of weakness, as will appear by the following Extract from the Survey made by the officers of Plymouth Yard, on that ship, by order of the Lords Commissioners of the Admiralty:

"When we consider the nature of the lading that this ship has brought home, with the temporary security to the beams of all the decks, except the orlop, and that on her passage she encountered four very severe gales of wind, it must, we presume, be very gratifying to

your Honourable Board to find, that she does not indicate any past symptoms of weakness or straining in any part."

This ship had no other attachment for her beams than the internal hoops and thick waterway; the remainder of her security, the iron knees, being omitted (from the difficulty of procuring them in India) until her arrival in this country; thus supporting her cargo without the aid of knees, either of wood or iron.

Sir Robert Seppings' improvements are not, however, confined to those portions of a vessel to which we have already had occasion to allude: the stern has more immediately engaged his attention. Mr. Harvey, of Plymouth, has very fully examined this part of the subject; and his observations will suffice for a clear and comprehensive view of the matter. In the mechanical construction of a ship, every part of its structure ought to possess a proper degree of strength; no one part possessing—if such an expression may be made use of—more strength than is absolutely necessary, nor any part less strength than the nature and office of that particular part is destined to maintain. And it is in the due adjustment of the several parts which constitute the frame of a ship, considered as a system of mechanical forces, that the science and judgment of the naval architect find so wide a field for the exercise of his powers.

Where a general similarity of construction prevails, it is impossible to derive any information from comparison: no advantage, for example, could be derived from comparing the square stern of another, supposing equal skill to have been employed in their construction; but we may arrive at some satisfactory information, by contrasting the strength and firmness of structures of different forms,—the strength of the stern of a ship, for example, with that of the stem. It may indeed be urged, in opposition to such a comparison, that, independent of the dissimilarity of form, which at present actually exists, between the stem and stern, the duties which they are destined respectively to perform are so very opposite to each other, that nothing satisfactory could be hoped for from the comparison. The dissimilarity of form, and the distance in the respective offices of the parts just alluded to, will be immediately admitted. But if it should appear on examination, and by an appeal to authentic documents, that a weakness in the stern is much more common than in the bow, then will both these objections be fairly disposed of, and a superiority in the formation of the bow, over that of the stern, will be the necessary consequence.

The change which Sir Robert Seppings contemplates, and which

he has actually applied to several ships, is, to communicate to the stern the strength and firmness of the bow; and to continue the diagonal system of building, which he has lately introduced, round the stern, in order to make the strength of the fabric uniform and complete. It is now universally admitted, that the diagonal system has communicated great strength to every part to which it has been hitherto applied; and there seems no good reason why the same increase of strength should not be communicated to a part so notoriously weak as the present square stern, particularly when by doing so not only the mechanical frame of the ship is materially strengthened, but its means of defence also very much increased.

The next point of view, in which this important subject may be contemplated, is the consideration of the means which each form of the stern affords for attack and defence.

In the first place, the same objections may be urged against the defence of a square stern, as is known to attach to a redoubt of a square form. "Redoubts," says Malorti de Martemont, in his theory of Field Fortification, "when they are not flanked by some other fire, have two essential defects: the first is, that their saliants are unprotected, which cannot be remedied but by adapting to those saliants a few teeth of cremaillere, or, when the ground and every other circumstance will allow it, by directing the saliants towards some inaccessible points, or by placing in front of them, when possible, some artificial obstacles." "But," continues Malorti, "circular redoubts have not that defect, as their fire, which has no fixed direction, may incessantly vary, and spread itself on every point of the ground that surrounds them;" and, "the defence which they present is uniform on every part of the circumference." Now the defects which this able writer attributes to square redoubts, hold, in all their force, against the defence of the square stern; while the reason he gives in favour of redoubts of a circular form, appplies most favourably to ships with round sterns. If we may be allowed, by way of illustration, to borrow a few terms from the practice of field fortification, to apply to the mode of defending a ship of war, we may, without impropriety, say, the "saliants" of the square stern are unprotected; that we cannot apply to those "saliants" a few teeth of "cremaillere;" much less direct the "saliants" towards "inaccessible points," or erect in front of them "artificial obstacles." But that the fire of the circular stern is without "a fixed direction," because it will "spread" itself over every point of the ocean that surrounds it, and, moreover, that its defence will be found "uniform" in every part of the circumference. It is

true, that the defence of the stern only includes the form of a semicircle, while the defence of the redoubt here alluded to, embraces the whole range of its circumference; still the reasoning holds good for the latter figure as well as for the perfect circle, because the chord of the semicircle, in the case of the circular stern, requires no defence.

"In the event of future wars," observes Sir Robert, "an alteration in the form of the stern of our ships of war would, in all probability, be absolutely necessary; by which the guns may be worked with greater effect and facility, in consequence of the introduction of steam vessels: and that America is firmly convinced that a system of attack, by this description of vessels, is not only practicable, but that it will also be destructive in its operations, is not to be doubted." "Indeed," continues Sir R. "I have been told, from good authority, that they have lately well manned one of their frigates, given the command of her to a good officer, and directed an experiment to be tried, if a vessel propelled by steam could not, under any circumstances, lay on the quarter of the ship she attacked; and the result was completely in favour of the steam vessel." If we inquire into the cause of this failure, we shall undoubtedly find, that the frigate was incapable of defending her quarter, owing to the square form of her stern,—a circumstance which would not have taken place, if she had possessed one of a circular form.

In case of an attack of the kind just alluded to, Sir R. Seppings' plan gives a superiority, not only on account of the additional number of guns which the ship is enabled to bring into action, and the sweep of the ocean which those guns are able to command; but also, an advantage of another kind, arising from the diminution of the distance of that point from the ship where the shot from the two after-guns cross each other, when the guns are trained to their greatest angle,—a point, it is presumed, of no small importance in case of an attack from a steam vessel. In an 84-gun ship, with a square stern, this point is distant from the stern, on the level of the gun-deck, about 18½ feet, and from the upper deck about 16 feet; whereas, in the circular stern the same point on the gun-deck is distant only 12 feet, and from the upper deck but 13. In the case of a 60-gun frigate, the distance of a similar point from the square stern is nearly 16 feet, while, in the circular stern, it is only nine. These united considerations tend unquestionably to prove, that the circular stern is the form best capable of defence.

The sentiments of so distinguished a man as Dupin, on a question of this nature, are entitled to the highest consideration; and it is

most pleasing and satisfactory to peruse the candid and sensible remarks he has made on the subject of round sterns, in his different valuable works. "It is in the sterns of their ships," says he, "that the English, at this time, carry into effect a great improvement. For the future (it is to be wished that the liberal views of Dupin were completely realised in this point) the sterns of their ships are to be circular, composed of timbers, and planked up in the same manner as the sides of the ships. They are to be pierced with ports, shut in with solid port-lids, (below). The ships of three decks, for example, present four vertical ranges of four ports each, to fight when in retreat, which, in proportion to the breadth of the ship, present a force equal to that of ships the best armed in their sides. In the (square) stern, the many glazed windows, and the munnions of fir, are the only defence; notwithstanding, a shot which comes into a ship from aft forward, or from forward aft, causes ten times the destruction which a shot does which comes in at one side and passes out at the other. Act contrary, then," continues this enlightened author, "to what has hitherto been the practice, and, if possible, make the means of defence of the part most exposed, ten times as great as it now is: reason, at least, demands that this should be done.

"I ardently wish to see these improvements introduced into our ships. I have constantly repeated, since my first journey into England until this day, every argument, every observation, every experiment, which have appeared to me to carry conviction to the mind. Prejudices and objections, which it is impossible to overcome, except by the aid of time, have presented themselves; but over these, time will necessarily triumph."

Dupin has alluded to prejudices; and, unfortunately, objections, having no better foundation, have existed, and do still exist, in this country, against this most important plan. Among these prejudices, one may be mentioned, which has given rise to objections respecting the want of beauty in the external form of the circular stern. It will not be contended, but that, according to the mode in which the eye has been hitherto educated, the appearance of the square stern is rather more beautiful than that of the circular form; but the influence of education, it has often been remarked, is impotent, and time will do much for the appearance of the new plan. Is it not, however, trifling with a subject of so very important a nature, to sacrifice utility to appearance? Ought the sound principles of a genuine mechanical construction to be abandoned, because the eye has been wedded to a particular form? Ought not the primary objects for which a ship of

war was constructed, to be consulted, rather than any ideal notions, relating to a subject so very abstract and uncertain as that of beauty? A ship of war should be contemplated at all times—whether in an actual state of warfare, or during a period of tranquillity and peace—as a floating castle, possessing all the essential elements of durability and force, and capable of acting under all situations, whether of an offensive kind, with equal power, certainty, and success. This, it must be admitted, is the idea which ought ever to be associated with a British man-of-war, destined, as it is, to act under circumstances so very varied and uncertain. Objections relative to appearances should cease; and even convenience ought to be surrendered, if necessary, when so many advantages are likely to be obtained. "Ornament and decorations can only be perfectly beautiful," as Dupin ingeniously observes, "when the appearance of force commands respect from the enemy." "What should we say," continues this judicious observer, "of a military engineer, if he were to substitute for thick walls, and the massive gates of curtains, glass doors, to please the fancy of the officers of the place? Yet," says he, when referring to the square sterns, "here are the glass doors which we open in the curtains of our floating fortresses.

In concluding these remarks, therefore, it may be observed, that Sir Robert Seppings, in his letter to Lord Melville, has most unquestionably demonstrated two essential and important principles, namely, first, that a ship's stern, when constructed of a square form, is weak and feeble, when compared with the present general structure of the vessel; and, secondly, that vessels with sterns of the same form, are incapable of making a strong and vigorous defence, when attacked by a powerful force in that part: but that vessels with circular sterns possess qualities and powers precisely the reverse, exhibiting strength where weakness is invariably found in the old form; supplying all the defects attendant on that mode of construction; giving strength to the entire mechanical frame of the ship, and affording increased security and power to the gallant men who navigate and defend her.

Having, in the preceding pages, examined the various plans connected with the out-board works, as well as the improvements suggested by Sir Robert Seppings, it may now be advisable to notice, prior to our examination of the internal arrangements, the keel, with reference to Captain Schanck's suggestions for the improvement of that important part of the vessel. The speed of a vessel does not depend so much upon the form of the bow as it does on the depth to which it is immersed in the water. Captain Schanck has stated very

stated very properly, that in the case of a frigate drawing seventeen feet water, and another frigate of the same burthen drawing only eleven feet, the last will have a body of six feet less fluid to divide, opposing only one, two, or three keels, as may be found necessary, to make her hold a good wind, while the first has six feet perpendicular depth of her hull depressed, being about one-third of her real size. It follows, therefore, she has a body of water to displace, and force herself through, equal to the difference between eleven and seventeen; when it is considered, in addition to this, that the resistance of the fluid rapidly encreases in proportion to the depth it is acted against, the disparity is almost incredibly encreased. North-country built vessels, or those in the coal-trade, are a strong proof of this observation. These, in general, draw one-third less water, than any other of British construction; yet, when employed as transports, they are generally found to sail as fast as any others; and, when going before the wind in ballast, or half loaded, frequently beat the ships belonging to the Royal Navy. When, however, they are close hauled on a wind they will drop to leeward; but, were they furnished with sliding keels, there is no doubt but that they would have the advantage over all the other English vessels. The Dutch, who bestow little pains in making their trading vessels sail, are nevertheless not totally unfortunate in this respect; for when they are light, they sail fast before the wind, owing to their small draught of water. They have also other vessels built almost totally flat, such as pilot boats, yagers for carrying the first herrings to market from Shetland, and pleasure yachts. All these have lee-boards, by the assistance of which they sail as fast as the generality of those which navigate the Northern Seas; circumstances which are manifestly in favour of flat-floored vessels and sliding keels.

In regard to the sailing trim of a vessel, it is the decided opinion of most scientific men, that ships or vessels of the larger classes should always be so constructed as to sail on, or nearly on an even keel, that is, so that the ship, when trimmed for sailing, should have her keel parallel to the surface of the water; therefore by as much as the effort of the wind on the sails and masts in forcing the ship through the water has a constant tendency to depress the bow, so much should the ship be trimmed by the stern, as that will be found most advantageous both to their sailing and steering.

Many think it inconsistent to construct a ship to sail on an even keel, and yet to place the midship-bend or greatest breadth very forward. A ship so intended to sail, ought, as they conceive, when launched, to have an equal bearing fore and aft, which must inevitably

strain the body of the ship. And yet, experience convinces us it is not materially detrimental; for many ships, when launched, will swim four feet by the stern, more or less, and yet when trimmed for sailing, they are found to go faster on an even keel, and receive little or no damage if carefully stowed.

Some ships are too clean abaft, and require to sail by the stern; because they have no bearing for fifteen or twenty feet from aft, till the buttock is brought well into the water; and even then, for want of being fuller lower down, when the sea leaves the buttock, the overhanging of the stern will strain the ship, and occasion her to tremble, till the next sea, with redoubled force, strike the buttock as the stern is falling, and so shake the ship: in which case it will be well, if some parts of the masts be not carried away by the shock: however, this kind of motion must retard the velocity. This accident, though rare, is dangerous, and should be prevented in the construction of the ship.

With respect to the ships that ought to sail some feet by the stern, on account of their insufficiency abaft, it is the opinion of many, that if a line were drawn to be well with the lower side of the keel, in the middle of the ship's length; and half the difference set up at the aft-part of the stern-post from the lower side of the keel, and that part of the keel and dead-wood were taken off, and placed under the fore-part of the keel, with the after-end that was before to be forward, so as to make the lower part of the keel straight, as before, the ship would then sail somewhat faster, and be the better: for when a ship is brought so much down by the stern, the keel, not being parallel to the surface of the water, (to which the ship generally sails parallel,) must occasion a pressure at the under side of the keel, equal to the weight of water displaced by the breadth of the keel, and to the angle which the keel makes with the surface of the water in its own length. This may shew why so many ships, differently constructed, are found to sail best on an even keel, although many of them were designed by the constructor to sail by the stern. By that means the water-lines were drawn parallel to the keel, and were thereby more useful as well as more properly placed to form the body; for when the square timbers, and the water-lines, being square to the timber, properly agree with each other, and are fair curves, the ribband-lines, or any other section, will likewise be fair, or as fair as they should be, allowing the preference to the water-lines and square timbers.

It is a point too well known to every person conversant in naval architecture to need explanation, how far the different constructions of

vessels will occasion a variance in the quantity those actually of the same measurement will carry. Ships built sharp forward and aft, lose a considerable portion of stowage; while some vessels have the floor so straight throughout the whole of their length, that by looking down in the holds of one, and of the other, the difference is easily discernible by the eye. For this reason it is impossible a true measurement ever can be made; and the assertion may be regarded, perhaps, that notwithstanding all which the respectable and learned men of different nations have written on the subject, no certain method will ever be discovered of ascertaining the true capacity of vessels, until they shall be built with greater resemblance to each other, even in the upper works, as well as in the lower part of the hull. It has frequently been observed by officers and others, who have had occasion to inform themselves practically on the subject, that many ships of the same measurement will not take in nearly the quantity they are estimated to carry; while others, exclusive of the quantity of goods or stores, which their constructors allotted to them, can receive a still additional cargo, and carry it with ease. It has been observed too, that if sharp-built vessels are at any time capable of containing the amount of their calculated tonnage, they are never able to carry it with the same ease that vessels of flatter construction are, inasmuch as their form forward and aft will inevitably occasion their pitching and shipping water. This inconvenience has been observed to proceed invariably from the cause just assigned; for a sharp-built ship sinks under its cargo so fast, that by the time it comes to its bearings, it is frequently not nearly loaded. Those having flat and long floors, on the other hand, sink slowly; and after having taken in the quantity they measure, will have, frequently, plenty of room, and remain high out of the water: so that it has happened, not only that an additional cargo has been taken in, but that, when two vessels of the same measurement, though of contrary constructions, have been laden at the same time, the flat-floored vessel has been enabled to carry, in all respects fitter for sea, what was necessarily rejected by her companion; and, after taking on board the whole of her additional cargo, still continued in the best state of trim. It appears, therefore, to be the opinion of many ingenious naval architects, and of Captain Schanck in particular, that one of the first desiderata in the improvement of the art of ship-building, would be to try experiments on the general use and introduction of long flat floors, which are supposed, by many, to promise, under certain regulations, the most extensive advantages.

The only objection that can be advanced in opposition to this system, is, the inaptness of a flat-floored vessel to hold a good wind, a difficulty which may be instantaneously removed by the adoption of sliding-keels; provided they are found, on more critical enquiry, to answer the intended purpose, without occasioning injury to the vessel, or material inconvenience to the mariners.

To return then to the examination of those arguments which are adduced in favour of this new contrivance, it is, in the first instance, agreed as a preliminary, and the fact is certainly too obvious to admit of the smallest cavil, that vessels so built, must inevitably draw less water than those of any other form. This being admitted it will be necessary to state the various advantages that have been experimentally found to result from the encouragement of this system, and those which, in theory, may, in addition, be expected to be derived from it. The same principle which causes flat-floored vessels to sail faster before the wind, to carry a superior cargo, and draw less water, will operate with equal force in rendering them easy at anchor. Experience, and the occurrences of many years, prove that the North Country-built ships, all of which have flat floors, and the Dutch fishing-boats will ride at anchor, when the violence of the wind and sea would render it extremely dangerous, and, perhaps, impossible, for those of any other construction to persevere in the same measure. Their form, with the fulness of their body fore and aft, enables them to rise and fall, according to the lift of the sea, with the greatest ease to themselves; while, on the contrary, sharp, and, as they are commonly called, clean built ships, pitch with the utmost violence, frequently with such force as to endanger the instantaneous loss of all the masts; to say nothing of the strain which the suddenness of the tremendous jerks must give the hull, and the injury the anchors and cables are in momentary danger of experiencing from the same cause. Captain Cook, whose practical knowledge in navigation, and the properties of a vessel, stood, perhaps, inferior to that of no person in the world, gives a decided preference in favour of the flat-floored vessel, as being best calculated for a distant and perilous voyage, in consequence of her peculiarly possessing those valuable properties just enumerated.

In 1663, Sir William Petty constructed a double ship, or rather a single ship with a double bottom, which was found to sail considerably faster than any of the ships with which it had an opportunity of being tried. Her first voyage was from Dublin to Holyhead; and in her return, "she turned into that narrow harbour against wind and tide,

among rocks and ships, with such dexterity, that many ancient seamen confessed they had never seen the like."

This vessel with 70 more were lost in a dreadful tempest. This subject was again revived by Mr. Gordon, in his principle of Naval Architecture, printed at Aberdeen, anno 1784; where, having delivered his sentiments on the construction of large masts, he says: "These experiments likewise point out to us methods by which two vessels may be laterally connected together, though at a considerable distance from each other, in a manner sufficiently strong, with very little increase of weight or expense of materials, and without exposing much surface to the action or influence of the wind or the waves, or obstructing their motion in any considerable degree, and consequently without being much opposed by them on that account under any circumstances; and if vessels are judiciously constructed, with a view to such a juncture, it would be no easy matter to enumerate all the advantages that may be obtained by this means." He then enumerates the advantages, that double vessels would have over those of the common construction. Soon after double ships were actually built by Mr. Miller, of Dalswinton.

Another plan was proposed by Mr. Gordon, to make a ship sail fast, draw little water, and to keep a good wind. For this purpose, "the bottom (he says) should be formed quite flat, and the sides made to rise perpendicular from it, without any curvature; which would not only render her more steady, as being more opposed to the water in rolling, but likewise more convenient for stowage, &c. while the simplicity of the form would contribute greatly to the ease and expedition with which she might be fabricated. Though diminishing the draught of water is, of all others, undoubtedly the most effectual method of augmenting the velocity with which vessels go before the wind; yet, as it proportionally diminishes their hold of the water, it renders them extremely liable to be driven to leeward, and altogether incapable of keeping a good wind. This defect may, however, be remedied, in a simple and effectual manner, by proportionally augmenting the depth of keel, or, as so large a keel would be inconvenient on many accounts, proportionally increasing their number; as, in place of adding a keel eight feet deep, to a vessel drawing six feet water, to affix to different parts of her flat bottom, which would be well adapted for receiving them, six different keels of two feet deep each at equal distances from each other, with proper intervals between, which will be found equally effectual for preventing these pernicious effects. Four such, indeed, would have answered the

purpose as well as the eight feet keel, were it not for the superior pressure or resistance of the lower water."

Thus then it appears, that a vessel drawing eight feet water only, keels and all, may be made to keep as good a wind, or be as little liable to be driven to leeward, as the sharpest built vessel of the same length drawing 14, nay 20 or upwards, if a few more keels are added, at the same time, that she would be little more resisted in moving in the line of the keels than a vessel drawing six feet water only. These keels, besides, would strengthen the vessel considerably, would render her more steady, and less liable to be overset, and thereby enable her to carry more sail; and Mr. Gordon then enumerates the several advantages that a ship of this construction will possess.

This plan has lately been put into execution by Captain Schank, with this difference only, that instead of the keels being fixed as proposed by Mr. Gordon, Captain Schank constructed them so as to slide down to a certain depth below the bottom, or to be drawn up within the ship as occasion might require.

Captain Schank having communicated his plans to the Navy Board, two vessels were in consequence ordered to be built of 13 tons each, and similar in dimensions, one on the old construction, and the other flat-bottomed, with sliding keels. In 1790 a comparative trial in presence of the commissioners of the navy was made on the river Thames, each having the same quantity of sail; and although the vessel on the old construction had leeboards, a greater quantity of ballast, and two Thames pilots aboard, yet Captain Schank's vessel with three sliding keels beat the other vessel, to the astonishment of all present, one half of the whole distance sailed; and no doubt she would have beat her much more had she been furnished with a Thames pilot.

This trial gave so much satisfaction, that a king's cutter of 120 tons was immediately ordered to be built on the same construction, and Captain Schank was requested to superintend its building. This vessel was launched at Plymouth in 1791, and named the Trial. The length of this vessel is 66 feet, breadth 21 feet and depth of the hold 7 feet: her bottom is quite flat and draws only six feet water, with all her guns, stores, &c., whereas all other vessels of her tonnage on the old construction draw 14 feet; so that she can go with safety into almost any harbour or creek. She has three sliding keels inclosed in a case or well; they are each 14 feet in length; the fore and the after keels are 3 feet broad each, and the middle keel is 6 feet broad. The keels are moveable by means of a winch, and may be let down

7 feet below the real keel; and they work equally well in a storm as in still water. Her hold is divided into several compartments, all water-tight, and so contrived, that should even a plank or two start at sea in different parts of the vessel, she may be navigated with the greatest security to any place. If she should be driven on shore in a gale of wind, she will not soon become a wreck, as her keels will be driven up into their cases, and the ship being flat-bottomed, will not be easily overset; and being able to go into such shallow water, the crew may all be easily saved. By means of her sliding keels she is kept steady in the greatest gale; she is quite easy in a great sea, does not strain in the least, and never takes in water on her deck; and when at anchor, she rides more upright and even than any other ship can do: she sails very fast either before or upon the wind; no vessel she has ever been in company with, of equal size, has been able, upon many trials, to beat her in sailing; and yet her sails seem too small.

The use of sliding keels is known by actual experience to be of the greatest importance. In fresh breezes, or in light winds, it is totally immaterial how much sail is set, or how it is disposed; since the act of raising or lowering the keels will immediately counteract the inconvenience that might otherwise arise from carrying too much sail, either forward or aft. The most trifling practice will render the navigators perfectly acquainted with their use, and the easy steerage of this ship will convince him of their advantage. In a gale of wind it is necessary that the main and fore keels should be hauled close up, and the stern keel let down to such depth as shall be found necessary to make the vessel steer perfectly easy.

The inventor expresses himself as absolutely certain, that in case the very plain and simple instructions last given are carefully followed, no misfortune, similar to that of broaching to, can ever befal a vessel furnished with sliding keels. "How pleasing," he observes in the latter part of this description, "must be the reflection in the minds of all persons on board, that they are strongly and unassailably guarded from the intervention of such an incident; but more especially how tranquil, under such a recollection, must be the mind of him to whom the safety of the ship, and the lives of the people on board, is committed; whose memory may suffer from an accident, which neither his prudence nor his courage could foresee or prevent, and to which he himself falls the unfortunate unerring victim."

To pursue the details still further: vessels furnished with two or three sliding keels will tack with far greater readiness than those which

are destitute of them; because the fore and stern-most keels have each of them an effect on the vessel, very little inferior to that of the rudder itself. In working therefore to windward, or in a narrow channel where there is little room, a vessel may venture to stand much nearer to the shore than she otherwise would do, being certain of not missing stays. The measures recommended to be taken in putting about, are, to haul up the stern-mast, and immediately to let the fore-keel completely down, putting the helm a-lee at the same instant, the ship will come round almost incredibly fast; so that instead of that sloth, if the term be allowed, with which the yards of a vessel going about, may frequently appear to be worked in the eyes of those who are unacquainted with the art of navigation, it requires no inconsiderable share of alertness in the people to trim the sails sufficiently quick, particularly in a fresh of wind. The fore keel being hauled up as soon as the ship's head is brought to the wind, it is ready to prevent, as is generally the case with square-rigged vessels, any falling off, which occasions the loss of an infinite deal of time: the instant therefore that the sails are full, the fore keel being lowered down, will not only prevent any inconvenience of the kind just mentioned, but will cause the vessel, as soon as it gets any headway, to fly to, with as much alacrity as if going about; insomuch that some care must be taken to prevent the vessel from coming round, by trivially raising the fore keel, as soon as the head is brought in a position to lay the proper course.

The use of the sliding keel is equally advantageous in wearing as in tacking. The measures recommended to be taken are, reversing those of the former operation, to haul up the fore keel, and lower down the sternmost; or, if it is required that the weight should wear round quick, it will be necessary to haul up the main keel also, and the ship will turn almost as though it were on a pivot, the rudder being at the same time made use of in the customary way. The reason of the effect produced by the operation just described, will become immediately obvious, on the slightest consideration of the acting principle. The fore as well as main keels being hauled up, and the stern keel down, the latter acts in some degree as the rudder itself, and has a tendency to prevent the vessel from fore-reaching. The effect of the after keel, during this operation, is similar to that which would be produced by a rope made fast in the stem in the tideway: the moment the hawser or cable, which had previously kept the head of the vessel to the current, is cast off, the stern would naturally swing round, and take the same position. Or, to proceed with stating a parallel case, if a vessel drawing more water abaft than forward, should

chance to take the ground, and her bows, or fore-body, be afloat, the head will immediately swing round, as it were to oppose the current or tide.

By the tonnage of a ship, is meant to convey the idea of the weight of the cargo she is intended to carry from her light to her load-water-line, or seat in the water when best equipped for sea. It may also be called the ship's real burthen. Therefore, to ascertain the true burthen or tonnage by calculation, is a question of equal importance and difficulty, as preceding displacement, &c.

It is of importance, because it is by this that the merchant or freighter judges of the fitness of the ship for his purpose; and although customary rules are given for computing the tonnages of ships, the bare inspection of them will prove how futile they are. It would be very difficult to fix upon any general rule which shall be very exact, because it depends not only on the cubical dimensions of the ship's bottoms, but also on the scantling of her whole frame; and, in short, on the weight of every article to complete the said ship ready to receive on board her cargo. The weight of timber is variable; the scantling of the frame being no less so.

The following rules for computing the tonnage of a ship are commonly adopted and made use of between the contractor and the builder, at a certain rate per ton for the building, and will be found to be quite unconnected with the above definition of a ship's tonnage; for as the depth is out of the question, the contractor finds a saving in less breadth and great depth, which make against stability, and consequently injure the velocity: on the contrary, great breadth and less depth will be found more advantageous to the builder: thus are the interests of the two parties oppositely concerned in the result, and both, when carried to the extreme, are exceedingly injurious to the construction of vessels.

The general rules observed for measuring the tonnage of ships in the Royal Navy and the Merchants' Service.

Let fall a perpendicular from the fore-side of the stem, at the height of the upper deck, or middle deck, in three-deck ships, and another perpendicular from the aft-side of the main-post, at the height of the wing-transom. In merchant-ships, the foremost-perpendicular is let fall from the fore-side of the stem at the height of the wing-transom. From the length between these perpendiculars, deduct three-fifths of the extreme breadth, (that is the thickness of the bottom plank on each side added to the moulded-breadth,) and likewise as many $2\frac{1}{2}$ inches as the wing-transom is above the upper edge of the keel, and the

remainder is reckoned the length of the keel for tonnage.

Then multiply the length of the keel for tonnage by the extreme breadth, and that product by half the extreme breadth; then dividing by 94, the quotient will be the burthen, in what may be denominated builder's tonnage.

Calculation of the burthen in tons of a 74-gun ship, according to the common rule.

	Feet.	*Inches.*
Length from the fore-side of the stem, at the height of the upper deck, to the aft-side of the main-post, at the height of the upper side of the wing-transom	182	9½

	Ft.	*In.*
Three-fifths of the extreme breadth is	29	2⅝
The height of the wing-transom is 26 feet 10 inches, which produces for every 2½ inches	5	6⅞
	34	9½

	34	9½
Length of the keel for tonnage	148	0
Multiplied by the extreme breadth	48	8
	7202	8
Multiplied by half the extreme breadth	24	4
Divided by 94	175248	0
Burthen in tons according to the common rule	1864⅝⅝	

Estimate, showing the real burthen of the 74-gun ship,

	Tons.	*Pounds.*
The weight of the ship at the launching draught of water	1337	2198
The weight of the furniture, including the sheathing	204	1040
The weight of the ship at her light-water mark	1582	998
The weight of the ship at the load-water-mark	2829	175
From which deduct the weight at the light-water-mark	1582	998
Real burthen	1246	1417
Burthen in tons, according to the common rule	1866	762
Difference	617	1585

Centre of Gravity.

The centre of gravity of a ship, supposed homogeneous, and in a state of equilibrium is in a perpendicular section, passing through the keel, and dividing the ship into two equal and similar parts, at a certain distance from the stern and altitude above the keel.

To ascertain the centre of displacement, or centre of gravity, of the immersed part of a ship's bottom, in a state of equilibrium, begin by determining the centre of gravity of the upper horizontal section, or water-line; and as the two sides are equal and similar, the middle line may be considered as the axis of the equilibrium, in which the centre of gravity of that surface is to be found; and as the surface of the upper water-line, and so of the others, has been already divided into equal parts, and the breadths taken at the several timbers or ordinates to find the displacement, we have only to observe that the spaces between those timbers are here considered as so many parallelograms, the centres of gravity of which parallelograms will form a system distributed on the middle line.

Then to find the centre of gravity of the system, in respect to the aft-side of the rudder, which is assumed for the first term of the momenta, we need not find the centre of gravity of each parallelogram, but divide the whole surface into three sections, and multiply their sums, as before, by the distance between the ordinates, and the product will be the area of each section.

Then to obtain the sum of the momenta of all the elementary parts of the surface, multiply the breadth of each ordinate into its distance from the axis of the momenta, or first ordinate; then take the sum of all these products, and, by multiplying this sum by the distance between the ordinates, we shall have the sum of all the momenta of the elementary parts of the surface; which, divided by the sum of the ordinates, will give the distance of the centre of gravity of the whole surface from the axis of the momenta.

Lastly, the areas of the several planes or surfaces, and their momenta, being found, divide one by the other, and the quotient will be the distance of the centre of gravity of the whole section from the aft-side of the rudder.

Ship Building.

Plan of Iron Knee.

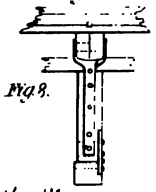
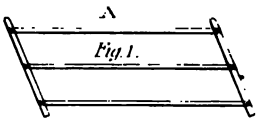
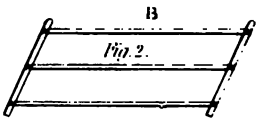
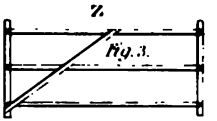


Fig 8.







Plan of the Stern.

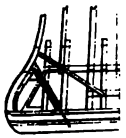


Fig. 9.

Fig. 4

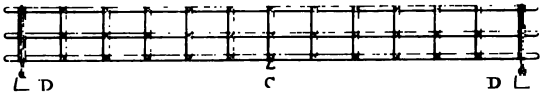


Fig 5.

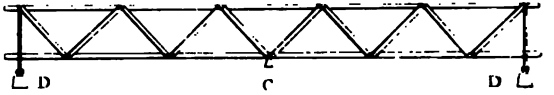


Fig 6.

Transverse Section.

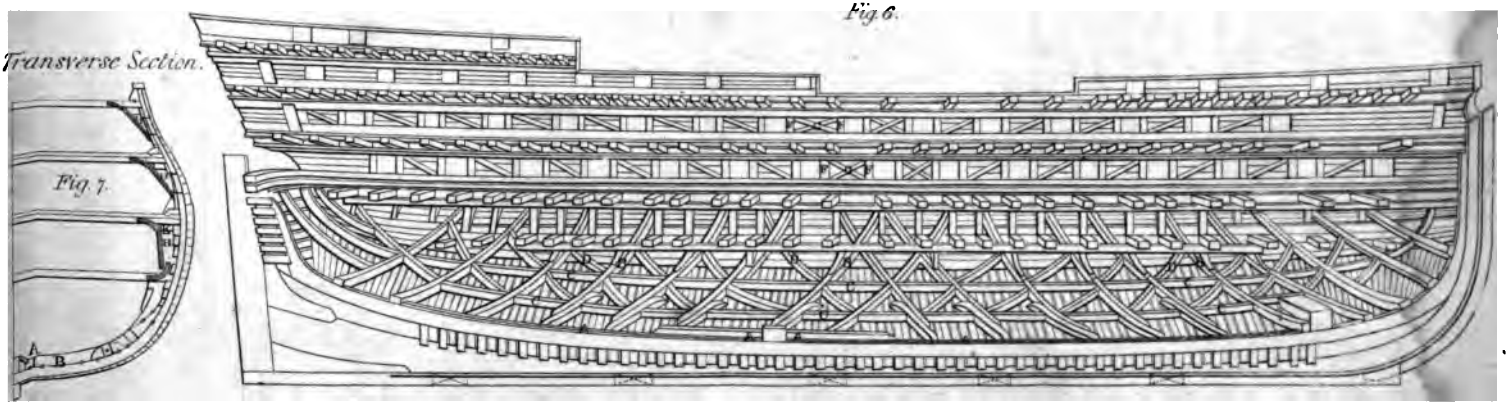


Fig. 7.

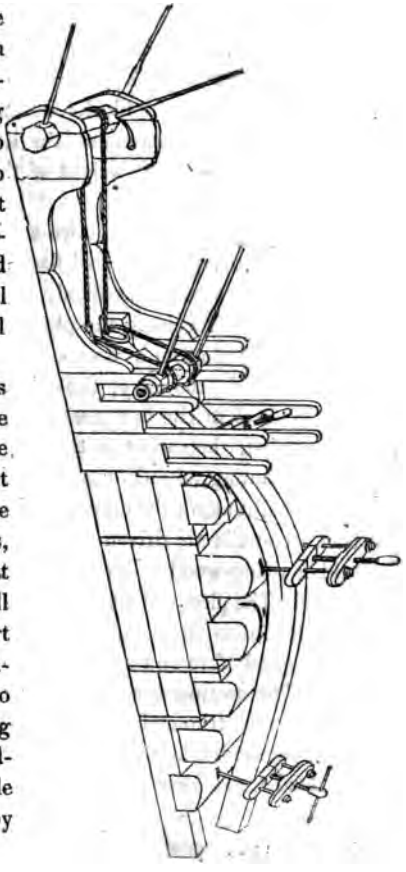
Bending Timbers.

Our previous notices have extended almost exclusively to the form of the vessel, we may notice the preparation of the timbers.

Mr. Hookey has invented a mode of bending the timbers of a large vessel which promises to be of great practical utility. It is intended principally for the preparing of floor-timbers, futtocks, breast-hooks, long riders, beams, and knees.

In the building of a seventy-four gun ship on Mr. H's plan, a saving will be made of about fifteen hundred pounds, and a general saving to the country of fifty thousand pounds per annum, in ship and boat building; and this is not the only advantage as the present mode will give a constant supply of timber, which cannot otherwise be obtained.

The timber is first sawn down to the middle, as far as it is to be bent, as shewn by the line in the different timbers, which greatly increases the power of bending it, and permits the one part to slide over the other, so as to lessen the tear of the different parts; which are afterwards secured together by bolts passed through them, and may be still farther stiffened, by additional pieces let into them.



The annexed engraving affords an opportunity of showing the handspikes or levers placed in the holes in capstans, by the joint action of which the timbers are forced into the requisite curves, to suit which the blocks must be previously arranged, as well as the beams which support them, and which are so managed as to form buttresses to prevent the blocks from shifting their places, in the act of bending the timbers; and the whole is securely united together by iron bands.

Commencement of the Hull.

A slip being provided, the blocks on which the keel is laid are usually about five feet asunder. Each block is laid upon a ground-way in the middle of the slip, unless a smaller vessel is intended to be built where the launch has been laid for a large ship. In this case, by keeping the blocks towards one side, the sliding-planks may be preserved for that side.

The blocks, being the foundation of the whole, must be very carefully fixed, and their upper surface to a declivity of five-eighths of an inch to every foot in the length, observing that there may be water enough to launch the ship into, and keeping them high enough at the fore-part to clear the fore-foot of the ground-ways in launching, and to admit of the sliding planks to be laid with a declivity of about seven-eighths of an inch to a foot.

The caps, or upper blocks, should be more in depth than the false keel; and they should be clear-grained oak, that they may split out the easier when the false keel is put under.

The upper sides of the blocks are made straight fore and aft, and level athwartships; sometimes the after-blocks are raised above a straight line, as the great weight of the stern and overhanging generally settle in building.

The keel is generally elm, sawn straight and square, and is scarfed together with coaks, with tarred flannel between each scarf, which are firmly bolted together and calked.

The rabbet for receiving the plank of the bottom may be trimmed out, leaving about a foot at each end of the scarfs, for the better calking the butts. In the navy, the rabbet is lined parallel to the upper side of the keel to the thickness of the bottom plank; but in most merchant-ships, the rabbet is taken out of the middle of the keel, to prevent its canting, should the ship take the ground. The keel is set fair and straight along the middle of the blocks; and, to keep it in that position, tree-nails are driven along its sides into the blocks.

Dead or rising-wood is of oak timber, and fayed upon the upper side of the keel. The pieces along the mid-ships are of a parallel thickness, and in breadth to overhang the keel about two inches on each side. The dead-wood afore and abaft, for the security of the half-timbers, is as high as the cutting down. This part of the dead-wood below the stepping-line is trimmed to the shape of the body, and above the stepping, perpendicular to the size of the keelson. The scarfs or butts of the dead-wood should give scarf to the butts of the keel, and to each other.

The stem is composed of two or more pieces of oak-timber, of the

best quality, as shifting it is very expensive. It is sawn to its siding and moulding, then trimmed and scarfed together as the keel, and the rabbet taken out likewise.

On the stem should be marked, from the mould, the heights of the harpins, decks, cheeks, &c. and a line square from the keel, and a middle line as a guide to set it by.

Apron is also oak sawn to its siding and moulding, and fayed to the aft-side of the stem, to succour it at the scarfs, which are bolted through the apron, observing to place the bolts within the rabbets.

Bollard-timbers are oak sawn to their siding and moulding, their heads in wake of the bowsprit to be left the thickness of the plank inside and out; they are fayed and coaked to the sides of the stem and apron, and bolted through, when practicable, observing to place the bolts clear of the deck-hooks. Sometimes oak fillings are fayed between the stem and bollard-timbers to keep them more open in wake of the bowsprit.

Hawse-pieces are oak sawn to their siding and moulding, and are fayed to the bollard-timbers, and to each other, in wake of the hawse-holes, and are opened above and below the hawse-holes, for the admission of air, to about one inch and a half. When in their places, they are to be bolted to the bollard-timbers, and each other, clear of the hawse-holes and breast-hooks. Let it be observed, that the hawse-pieces should be so disposed as to be equally cut by the hawse-holes.

Stern-post is oak sawn to the siding and moulding, and should be provided for the top, and to work upwards, if to be got. The rabbet is trimmed out on each side, to receive the plank of the bottom, to the shape of the body; and a tenon left on the heel, one-third the depth of the keel.

Inner-post is oak sawn to a parallel breadth, and sided, as the shape of the body may require, below the head: it is fayed to the fore-side of the stern-post, and a tenon is made on the heel as on the main-post, and the head left long enough to tenon an inch into the transom next above it.

Transoms are oak sawn to their siding, whether rounding upwards or straight; and to the moulding by their respective moulds. The wing-transom, if sawed only to the margin bevelling, may be brought in for other uses, if found defective; for transoms require much trouble and expense to shift them; the quality of the timber ought, therefore, to be of the best, and quite free from any defect whatever. In converting the transoms, let care be taken to work them top and butt alternately.

The transoms are to be trimmed with the greatest nicety, and then let on the post, with scores on each side of about an inch; observing the greatest exactness in letting them down, and that they stand at right angles with the middle line on the post. The ends, when cut off to the mould, are left one inch and a half longer, to tenon and face on to the aft-sides of the fashion-piece. The ends may be opened or mouthed, to admit the air.

Fashion-pieces are oak sawn to their siding, then the mouldings and bevellings; and, when trimmed, let on to the ends of the transoms, in the manner already described.

Frame-timbers are oak sawn to their siding, straight, and out of winding, then moulded and sawn to their respective bevellings, except the cant-floors, which are sided to their proper cant.

The frame-timbers should be made out of sound well-grown timber, without sap or vein appearing in wake of the ports, and sawn full to their sidings, so that their scantling may remain after the ports are trimmed out. Every timber should also be provided to its length, consequently each should stand upon its proper head; or if one timber happens to be short, provide the next long enough to make good the deficient length, as through-chocks should always be rejected, or only admitted on extraordinary occasions. The heads and heels of all the timbers to have one-third of the substance left the moulding way, when trimmed; and the seats of the chocks should not exceed once and a half the sliding of the timber.

In providing the floors, care should be taken to reverse the butt end of each succeeding floor, because the tops may sometimes be scanty; and, when short of the floor-head, may be admitted, if the second futtock runs down and meets upon its respective floor.

All floors are required to have sufficient wood to seat themselves on the dead-wood, and the throats to run up to the cutting-down or under side of the keelson; than any wood wanting below the seating may be made good by a chock.

The floors, when correctly trimmed, are let down into scores cut in the dead-wood, to the exact height of the cutting down from the upper edge of the rabbet of the keel, in their respective situations; set precisely level, and at right angles with the middle line of the keel. The floors are then ribbanded and shored, securing the shores at the head and heels to prevent any alteration; for the truth and precision of the whole fabric may be said to depend upon the accuracy of the floors, when got into the ribband.

The several futtocks are trimmed straight, and out of winding

on the joint side; and the lower futtocks in the navy run down to the side of the dead-wood, but in merchant-ships they are from nine to twelve inches short of the keel, that water may not lie above the ceiling. The wood wanting on the inside of the lower futtocks, in the navy, is made good by cross-chocks up to the cutting-down.

The timbers that compose a frame, or bend, are bolted together, either close or opened, as required; the joint-side of the second futtock to the joint-side of the lower futtock, to the middle of its length or scarfing, and bolts thereto with three bolts of square iron. The keel of the third futtock joins the head of the lower futtock, and bolts, as the former, to the second futtock; the heel of the fourth futtock joins to the head of the second futtock, and bolts to the third; and the heel of the top-timber scarfs on the head of the third futtock, and is bolted or fastened with three nails to the fourth futtock, taking care that no bolts are driven in wake of the ports or port-fills.

They are raised into their places by sheers and tackles, and great care should be taken that the frame be not strained in hoisting, as its form would be altered, and of consequence the true shape of the body lost; to prevent which, the joints of the chocks and heads are secured by nailing quarter over them, and a shore fitted on the inside or bag of the frame.

The frames, as hoisted, are kept to their true breadth, and equally distant from the middle line, by the cross pales, which are nailed at the main height of breadth, or in the ports; the latter is preferable, if not thought too high, because the ends need not be cut, and they may remain till the ship is planked, and the beams in and kneed.

The frames are next ribbanded thus: the cant-frames may be got near to their stations by the harpin-moulds, then the harpins got up; and, if the frames come fair, may be nailed and shored to their sirmarks.

The square-frames, corresponding at the floor-sirmark or guide, must be levelled, and the joints set at right angles with the middle line, observing that the spacing of the ports agrees. The ribbands may then be nailed and shored, and the lower futtocks bolted to the floors.

Filling-timbers, or the timbers between the frames, are trimmed and hoisted into their places separately; then equally placed asunder, and nailed to the ribbands; then chocked at their heads and heels, and the whole frame dubbed fair inside and out to its scantling for planking.

Keelson is oak sawn to its siding and depth, or moulding, then fayed along the middle of the floors, and bolted through every floor and the keel, with three or more douls on each scarf, which should give as

much shift as possible to the scarfs of the keel. For some years a three-inch oak has been fayed upon the upper side of the keelson, and the bolts driven through that likewise.

Stemson is oak sawn to its siding and moulding, then trimmed and fayed to the apron, and scarfed with a hook or douls into the fore-part of the keelson. The bolts through the breast-hooks must be considered, and one or two bolts may then be driven through between them.

Sternson-knee is oak sawn to its siding and moulding, then trimmed and fayed against the transoms and upper side of the dead-wood, and scarfs with a hook, or douls into the after-piece of the keelson. It is bolted to the transoms and stern-post as the keelson, of which it is a continuation.

Wales are next wrought, and the thick-stuff below them; they should be fastened with dumps only for the present, as the tree-nail holes, which are double and single alternately in every timber, and should be left as long open as possible, for the admission of air. A doul in the timber next each butt in the wales, in the strake above and below it, has been lately introduced in the navy, as an additional security. The wales and diminishing strakes are then dubbed down fair, and large cleats nailed at the fore part of every port, to which the ship is substantially shored.

Planking.—The bottom is next planked down sufficiently low to work the orlop-clamps.

Inboard-clamps, thick-stuff, &c.—These are wrought similar to the outside stuff above. The clamps to the sheer of the deck, and their upper sides to the round-up of the beam, and the lower edge, square to the timbers, unless they work down to the ports; then, in wake of the ports, the lower sides are trimmed level, and between the ports square to the timbers. Clamps over ports are bearded from half their depth to one inch less in thickness on the under side, excepting over the ports, where the wood is left on, for the muzzles of the guns to house to; and the butts are douelled as the wales.

The thick-stuff is to be wrought with a square close edge over the joints of the timbers; and the spirkittings are to have a seam allowed, agreeable to the thickness with the outside stuff, which should be a full sixteenth to every inch in the thickness.

Beams are sawn to their siding, and to the moulded depth square to the siding. Beams of two, three, or four pieces, the middle pieces may be fir, excepting in the hatchways.

Beams in two pieces have a scarf one-third the whole length of the beam. Beams in three pieces have the middle pieces and the end

pieces each half the length of the whole beam, the middle having a scarf each way to take the arms. Beams made of four pieces have two middle pieces, each similar to the former: the arms and middle pieces are each to be in length three sevenths of the whole length of the beam.

Beams are either tabled or douelled, and bolted together at the scarfs: if tabled, the lengths of the table are once and a half the moulded depth in length, and divided at the middle of the depth; and where the wood is taken out on the upper side, it is left on the lower side, and so alternately; taking the wood out on the upper side at the table next the butt, as it will the better hang and support the lip. At each lip, beyond the tables, is a coak about six inches long; and next to that is a straight lap, about the same length.

The beams, when cut off to their length, have their ends mouthed and charred, and then are let down about one inch into the clamps, at their several stations, at right angles with the middle line; keeping their upper sides out of winding with the beam line.

Knees.—The beams, at their ends are connected to the sides by knees, or other substitutes for knees. The knees are sawn or trimmed to their siding, and fayed to the side, taking as little wood as possible out of the throat the moulding way, as the greatest strength of the knee is there. Each knee tapers towards the toe to which it is sided; and the substance in the throat should be about twice and a half the siding, and not to admit of any chock that would reduce the knee at any part less than the siding.

Each knee should have two douls in the beam-arm, and from three to four bolts; and the two upper bolts in the side-arm of the hanging-knees should be kept up as high as possible, and the others equally spaced to the toe, and bored as square to the side as the seams outside will allow.

In those parts of the ship afore and abaft, where wooden knees cannot be procured of kindly growth, (for upon that depends the strength) knees of iron are generally placed. These, although much used, particularly in merchant-ships, cannot be so fully depended upon as those of wood, because they cover less surface, are no wise flexible, nor can the bolts be driven so tight in iron as in wood. If, therefore, the ship strains, they must inevitably work loose. Again, the holes must be bored in the direction in which the knees are punched, so that where iron knees are intended to be placed, oak fillings should be driven between the timbers; otherwise the bolts may come in the openings, which is inadmissible. Besides this, the bolts may come in the

seams of the outside plank; when it so happens, the best way is to cut out a piece, and clench the bolt upon the timbers.

Bolts in wooden knees are mostly driven from the outside, and clenched upon the knees inside; but bolts in iron knees are driven from the inside, with collar or stout heads, because upon the head depends its fastening; or if the bolts be of copper, they must have a ring under the head, and the head spread or made large in driving. All bolts driven from the inside should be carefully clenched upon a ring, let flush into the plank, by means of a machine or centre-bitt for that purpose, and the points under water carefully caulked after the ring is let in.

Wooden knees having become scarce for some years past, many substitutes have been attempted; and iron knees, or rather knees formed of iron and wood conjointly, are certainly best when properly applied.

Standards, either on the deck or to the sides of orlop beams, are so similar to knees, as to require no further description.

Breast-hooks, steps, and crutches, are oak sawn to their sidings, then moulded. The deck-hooks are fayed to the timbers, the others to the inside stuff. The holes for the bolts are bored alternately, near the edges, equally asunder, and square with the body. Breast-hooks, steps, and crutches, are assisted in the moulding by chocks; and the deck-hooks may be assisted by large eakings worked behind them. All the chocks, &c. are douelled or tabled, and ought on no account to have less wood or substance than their siding, clear of the chock.

Riders are oak sawn to their siding, moulding, and bevelling; then fayed to their respective places, as follows.

Floor-riders in two pieces have a cross-chock fayed over the heels, with a hook and butt scarf; their heels run down to the limber-strake, and the heads run upwards between the joints of the floor-heads and first futtock heads.

First futtock-riders fay close to the sides of the floor-riders, and their heels extend downwards, within four feet of the keelson; their heads run upwards beween the joint of the first futtock-head and under side of the orlop-beams, with a cross-chock fayed over the heels as the floor-rider.

Second futtock-riders fay close to the sides of the first futtock-riders, and scarf with a hook-scarf under the head of the floor-riders, or connect thereto with a chock. Their heads run up within two inches of the under side of the gun-deck beam, and are sawn with a

The Launch.

swell at the orlop-beam, to which they tail sideways; and they bolt through the beam and the adjoining riders fore and aft.

The hull of the vessel, with reference to the labours of the shipwright being thus far considered, we may now briefly notice the *launch*, which is usually a period of much bustle and active preparation.

To facilitate the operation of launching, the ship, when she is first built, is supported by strong platforms, laid with a gradual inclination to the water; on the opposite sides of her keel, to which they are parallel. Upon the surface of this declivity are placed two corresponding ranges of planks, which compose the base of a frame, called the cradle, whose upper part envelopes the ship's bottom, to which it is securely attached. Thus, the lower surface of the cradle, conforming exactly to that of the frame below, lies flat upon it, lengthways, under the opposite sides of the ship's bottom; and as the former is intended to slide downwards upon the latter, carrying the ship along with it, the planes or faces of both are well daubed with soap and tallow. The necessary preparations for the launch being made, all the blocks and wedges by which the ship was formerly supported, are driven out from under her keel, till the whole weight gradually subsides upon the platforms, which are accordingly called the ways. The shores and stanchions, by which she is retained upon the stocks till the time of launching, are at length cut away, and the screws applied to move her, if necessary. The motion usually begins at the instant when the shores are cut, and the ship slides downward along the ways, which are generally prolonged under the surface of the water to a sufficient depth, to float her as soon as she arrives at the farthest end thereof. When a ship is to be launched, the ensign, jack, and pendant, are always hoisted, the last being displayed from a staff erected in the middle of the ship. Ships of the first-rate are commonly constructed in dry-docks, and afterwards floated out, by throwing open the flood-gates, and suffering the tide to enter, as soon as they are finished.*

* Docks are of various kinds.—1. Basins, or docks open to the tide, are called dry-docks, because the vessels frequenting them ground at low water, and lie dry on the ebb tide, and float again on the next rise of the tide. They are used at Liverpool as entrances to the wet docks, and are frequented by coasters, and small or light vessels, that do not injure by lying on the shore.

2. Graving docks, for repairing of ships, are excavations with flood-gates pointed towards the tide, to keep the water out while ships are under repair. Vessels are admitted at high water; and the gates are shut at low water; and when the repairs are completed, the gates are again opened before the rise of the tide, and the vessel is on the flood hauled out of dock. In some countries,

The Launch.

A ship, when launched from the stocks is furnished with one stream-anchor, and another which is termed a launching-anchor, somewhat heavier than the stream-anchor, hanging by stoppers to the cat-heads; by one or both of which she is first brought up, and afterwards warped to her "head and stern moorings," which are as follows. Across the bottom of the harbour or river, two chains, parallel to each other, if the bed of the river will admit of it, are extended at the distance of 200 feet from each other, by means of anchors, having only one fluke, which is sunk, and secured in the ground by piles, on the opposite sides, near low water-mark. To the rings of the anchors these chains are attached by a peculiar sort of link, called a "shackle." Each of these chains has, at about one-third of its length, a large iron ring, to which is fastened a chain, called an "up-and-down span;" which, lying on the ground, connects the parallel chains, and serves to keep them steadily in their places. At about 30 or 40 feet distance from each other, along each chain, chain-pendents, from five to nine in number, are fastened, having, at the end which connects with the ground work, a shackle; and at the other end, a link called a "Jew's-harp," through which the bridle or hawser of a ship, when moored is passed. The centre chain-pendent is fixed to the ring of the chain; and the number of the chains must depend upon the number of tiers required, each tier occupying two chains, because the ships are moored head and stern. But every tier does not always occupy two whole chains; because, unless a passage between the tiers is requisite, the chain to which the head chain-pendent of one tier is affixed, has likewise fastened to it the stern chain-pendent of the next tiers. These moorings are used in rivers or harbours of small extent, to which they are adapted; but in other places, not frequented by many ships, or of

---

where there is little or no tide, these docks are so constructed, as to have the water within forced out by pumps, or other mechanical operations, as in Russia and other parts.

In some places, as at Portsmouth, floating gates are constructed, in the form of a vessel, with each end like the bow of a ship, neatly fitted to the lock, and to work up or down a groove in the lock with the tide, by pumping water into, or out of the vessel, sufficient to float or sink it, as occasion might require. A vessel of this kind was also used at the London Docks, to keep the water out while they were making.

3. Slips for the building of ships, may be classed under this head. They also are excavations, sloping and inclined towards the tide, well framed and floored with timber, &c. Ships, when built, are generally launched at spring tides, by driving away the shores and props which supported them, when they are easily launched from off the slips.

considerable extent, there is another sort in use, called "swinging moorings." These differ from the former only in this; the ground work being the same. To the ring of the chain is fixed one chain-pendent, the end of which is passed through a large buoy; and to that is connected a swivel-ring by a shackle, and thus kept constantly from sinking into the ground. This is used for mooring one or two ships to. Near each end of the chain is fixed one chain-pendent, or more, supported likewise by a buoy, used only for the purpose of warping ships from the middle to any intended place.

To the "head and stern moorings," ships are thus fastened: clench the end of a bridle to the Jew's-harp of the chain-pendent, and pass it into the hawse holes; then heave it up, and bit it, like the after bridles, into the gun-room port, or in upon the quarters, and take a round turn round the beam of the after hatch, and cross it with a throat or round seizing; or, if more convenient round the jeer-bits. To moor to "swinging-moorings," pass out the ends of the bridle, one on each side, through the hawse hole next the stern; then pass them through the swivel ring of the chain-pendent; then return them into the ship through the after hawse holes, and bit them. In this situation a ship is fitted for sea, by regularly stowing her ballast, and getting on board her rigging, stores, &c.

The *steam boat* comes next in order, and the Soho will first claim our notice.

The Soho, which is one of the largest steam vessels built in Europe, was launched in July, 1823, intended to ply between Leith and London, a distance of about 460 miles. She is impelled by two engines of 60 horse power each; her length of deck is 163 feet; breadth 27; depth of hold 16 feet, 10 inches; burden 510 tons. Her accommodations are extensive, having space for 112 beds. The ladies' cabin is 8 feet high.

The Soho is, however, of somewhat smaller dimensions than the American steam-boat, the Chancellor Livingston, plying on the Hudson river between New York and Albany, constructed by Mr. Fulton. The following are some particulars respecting this vessel. Her keel is 154 feet long; deck 165; 32 broad; burden 520 tons; draught of water about 7 feet 3 inches; principal cabin 54 feet long, 7 high; ladies' cabin, above the other, 36 long, with closets; forward cabin 30 long, 7 high. Permanent sleeping-births, in principal cabin, 38; in ladies' cabin, 24; in fore cabin, 56; in captain's cabin on deck, 2; engineers and pilots', 3; forecastle, 6; fire-men, cooks, &c.; total, 135. Her engine is of 75 horse power; diameter of cylinder 40 inches

length 5 feet; piston rod 8½ feet; stroke 5 feet; boiler, 28 feet long, 12 broad, with two funnels; paddle wheels, 17 feet in diameter; paddle boards five feet, ten inches long, with two fly-wheels, each 14 feet diameter, connected by pinions to the crank wheel. The machinery rises 4½ feet above the deck. Average rate of sailing eight and one-half to eight and three-fourths miles an hour. With a strong wind and tide in her favour, she has made 12; but with strong wind and tide, against her, not more than six miles per hour. The hands employed on board are—13 mariners, 11 cooks, waiters, stewards, &c.; in all 24.

Barges are of various kinds, and require various names, according to the variety of their uses and structure: as,

A company's barge	A severn trow
A row barge	A ware barge
A royal barge	A light horseman
A sand barge	A west country barge.

A barge differs from a bark, as being smaller, and used only on rivers; whereas the latter goes out to sea.

There are also barges, belonging to men of war, serving to carry generals, admirals, and chief commanders.

Sailing barges are vessels with one mast, and sometimes a bowsprit. Those that have boom sails, are rigged like sloops; but, having few hands on board, the boom and gaff are more easily hoisted or topped, the power being increased by the addition of blocks. Sailing lighters or barges, with a sprit-main-sail, rig with a sprit-yard at the head of the sail, hanging diagonally to the mast. Some large barges have a ship's mizen, and a down hauler at the peek-end of the sprit-yard. Large barges have a fore-sail, jib, cross-jack-yard, and top-sail, similar to sloops.

The construction of *boats* may now be briefly noticed.

The largest boat that usually accompanies a ship, is the long-boat, which is generally furnished with a mast and sails: those which are fitted up for men of war, may be occasionally decked, armed, and equipped for cruising short distances against merchant ships of the enemy, or smugglers, or for impressing seamen, &c. The barges are next in order, which are longer, slighter, and narrower: they are employed to carry the principal sea-officers, as admirals, and captains of ships of war, and are very unfit for sea. Pinnaces exactly resemble barges, only that they are somewhat smaller, and never row more than eight oars; whereas a barge properly never rows less than ten. These are for the accommodation of the lieutenants &c. Cutters of a ship,

are broader, deeper, and shorter, than the barges or pinnaces; they are fitter for sailing, and are commonly employed in carrying stores, provisions, passengers, &c. to and from the ship. In the structure of this sort of boats, the lower edge of every plank in the side overlays the upper edge of the plank below, which is called by shipwrights, clinch-work. Yawls are something less than cutters, nearly of the same form, and used for similar services; they are generally rowed with six oars.

The above boats more particularly belong to men of war; as merchant ships seldom have more than two, viz. a long-boat and yawl: when they have a third, it is generally calculated for the countries to which they trade, and varies in its construction accordingly. Merchant ships employed in the Mediterranean, find it more convenient to use a launch, which is longer, more flat-bottomed, and better adapted every way to the harbours of that sea, than a long-boat.

A wherry is a light sharp boat, used in a river or harbour for carrying passengers from place to place. Punts are a sort of oblong flat-bottomed boats, nearly resembling floating stages; they are used by shipwrights and calkers, for beaming, calking, or repairing a ship's bottom. A moses is a very flat broad boat, used by merchant ships amongst the Caribbee-Islands, to bring hogsheads of sugar off from the sea-beach to the shipping which are anchored in the roads. A felucca is a strong passage-boat used in the Mediterranean, with from 10 to 16 banks of oars. The natives of Barbary often employ boats of this sort as cruisers.

The *life-boat* was invented by Mr. Greathead, and has been found of great utility in those situations in which an ordinary boat would have been swamped and destroyed.

The principle of this boat appears to have been suggested to Mr. Greathead, by the following simple fact Take a spheroid, and divide it into quarters, each quarter is elliptical, and nearly resembles the half of a wooden bowl, having a curvature with projecting ends; this, thrown into the sea or broken water, cannot be upset, or lie with the bottom upwards.

The length of the boat is thirty feet; the breadth, ten feet; the depth from the top of the gunwale to the lower part of the keel in midships, three feet three inches; from the gunwale to the platform (within), two feet four inches; from the top of the stems (both ends being similar) to the horizontal line of the bottom of the keel, five feet nine inches. The keel is a plank of three inches thick, of a proportionate breadth in midships, narrowing gradually towards the ends, to the breadth of the stems at the bottom, and forming a great convexity downwards. The stems are segments of a circle, with a considerable

rake. The bottom section, to the floor-heads, is a curve fore and aft, with the sweep of the keel. The floor timber has a small rise curving from the keel to the floor-heads. A bilge plank is wrought in on each side, next the floor-heads, with a double rabbet groove, of a similar thickness with the keel; and, on the outside of this, are fixed two bilge-trees, corresponding nearly with the level of the keel. The ends of the bottom section form that fine kind of entrance observable in the lower part of the bow of the fishing boat, called a coble, much used in the north. From this part to the top of the stem it is more elliptical, forming a considerable projection. The sides, from the floor-heads to the top of the gunwale, flaunch off on each side in proportion to above half the breadth of the floor. The breadth is continued far forwards towards the ends, leaving a sufficient length of straight side at the top. The sheer is regular along the straight side, and more elevated towards the ends. The gunwale fixed to the outside is three inches thick. The sides, from the under part of the gunwale, along the whole length of the regular sheer, extending twenty-one feet six inches, are cased with layers of cork, to the depth of sixteen inches downwards; and the thickness of this casing of cork being four inches, it projects at the top a little without the gunwale. The cork, on the outside, is secured with thin plates or slips of copper, and the boat is fastened with copper nails. The thwarts, or seats, are five in number, double-banked; consequently the boat may be rowed with ten oars. The thwarts are firmly stanchioned. The side oars are short, with iron tholes and rope grommets, so that the rower can pull either way. The boat is steered with an oar at each end; and the steering oar is one-third longer than the rowing oar. The platform placed at the bottom, within the boat, is horizontal, the length of the midships, and elevated at the ends, for the convenience of the steersman, to give him a greater power with the oar. The internal part of the boat next the sides, from the under part of the thwarts down to the platform, is cased with cork; the whole quantity of which, affixed to the life-boat, is nearly seven hundred weight. The cork indispensably contributes much to the buoyancy of the boat, is a good defence in going alongside a vessel, and is of principal use in keeping the boat in an erect position in the sea, or rather for giving a very lively and quick disposition to recover from any sudden cant or lurch which she may receive from the stroke of a heavy wave. But, exclusively of the cork, the admirable construction of this boat gives it a decided pre-eminence. The ends being similar, the boat can be rowed either way; and this peculiarity of form alleviates her in rising over the waves. The curvature

of the keel and bottom facilitates her movement in turning, and contributes to the ease of the steerage, as a single stroke of the steering oar has an immediate effect, the boat moving as it were upon a centre. The fine entrance below is of use in dividing the waves, when rowing against them; and, combined with the convexity of the bottom, and the elliptical form of the stern, admits her to rise with wonderful buoyancy in a high sea, and to launch forward with rapidity, without shipping any water, when a common boat would be in danger of being filled. The flaunching or spreading form of the boat from her floor-heads to the gunwale, gives her a considerable bearing; and the continuation of the breadth, well forward, is a great support to her in the sea; and it has been found by experience, that boats of this construction are the best sea boats for rowing against turbulent waves. The internal shallowness of the boat from the gunwale down to the platform, the convexity of the form, and the bulk of cork within, leave a very diminished space for the water to occupy; so that the life-boat, when filled with water, contains a considerable less quantity than the common boat, and is in no danger of sinking or overturning. It may be presumed by some, that in cases of high wind, agitated sea, and broken waves, a boat of such a bulk could not prevail against them by the force of oars; but the life-boat, from her peculiar form, may be rowed ahead, when the attempt in other boats would fail. Boats of the common form, adapted for speed, are of course put into motion with a small power; but, for want of buoyancy and bearing, are overrun by the waves, and sunk, when impelled against them; and boats constructed for burthen meet with too much resistance from the wind and sea, when opposed to them, and as such cannot be rowed from the shore to a ship in distress.

Mr. Greathead gives the following instructions for the management of the life-boat.

The boats, in general, of this description are painted white on the outside; this colour more immediately engaging the eye of the spectator when rising from the hollow of the sea, than any other. The bottom of the boat is at first varnished, though a painted surface is the most economical. The oars she is equipped with are made of fir, of the best quality; the inventor having found by experience, that a rove ash oar, that will dress clean and light, is too pliant among the breakers; and when made strong and heavy, from rowing double-banked, the purchase being short, sooner exhausts the rower, which makes the fir oar, when made stiff, more preferable.

Life Boat.

In the management of the boat she requires twelve men to work her, that is, five men on each side rowing double-banked, with an oar slung over an iron thole, with a grommet (as provided), so as to enable the rower to pull either way, and one man at each end to steer her, and to be ready at the opposite end to take the steer-oar, when wanted. As, from the construction of the boat, she is always in a position to be rowed either way, without turning the boat; when manned, the person who steers her should be well acquainted with the course of the tides, in order to take every possible advantage: the best method, if the direction will admit of it, is to head the sea. The steersman should keep his eye fixed upon the wave or breaker, and encourage the rowers not to give way, as the boat rises to it; being then aided by the force of the oars, she launches over it with vast rapidity, without shipping any water. It is necessary to observe, that there is often a strong reflux of sea occasioned by the stranded wrecks, which requires both dispatch and care in the people employed, that the boat be not damaged. When the wreck is reached, if the wind blows to the land, the boat will come in shore without any other effort than steering.

Mr. Christopher Wilson received a gold medal in 1807, for a life-boat with air gunwales, which was tried at Newhaven, and was said to be lighter and more manageable than Mr. Greathead's.

"Little is required," says Captain Manby, "to establish the importance and advantages that will result from giving every boat the properties of a life-boat, particularly when it is taken into consideration that it can be produced at a very trifling expense."

To illustrate the method of giving the properties of preservation to any boat, I have selected the representation of a man of war's jolly-boat, fitted up to make experiments thereon, by permission of the Honourable Commissioners of the Navy Board.

"To give it buoyancy, empty casks were well lashed and secured in it. For the advantage of keeping it in an upright position, launching from a flat shore, beaching, and to resist upsetting, it had billage boards of equal depth with the keel, and when a good sized piece of iron or lead was let into, or made fast to the keel, if any accident did upset the boat, it immediately regained its original posture. A stout projecting rope, with swellings upon it to increase its elasticity, surrounded the gunwale, served as a fender, and prevented it being stoved in lowering down, or when driven in contact with the vessel it might be going to relieve,

"The boat thus described had the plug out, and was filled with

water until it ran over the gunwale, when a crew of four with myself, tried it in every way, and found from the buoyant property of the casks, it kept the boat so much above the water's edge, that it was rowed with the greatest ease,and was capable of performing any service required."

Mr. J. Boyce, in 1814, obtained a medal for his life-boat and safety buoy, consisting of hollow cylinders, made of canvass, painted, and varnished, and connected with each other. It was tried on a river and and carried a man with safety ; but surely it could not be trusted among breakers on a lee shore. In 1818, Mr. Gabriel Bray obtained a silver medal for his invention of a boat filled with air boxes, under the seats and along the sides.

Captain Manby's proposal for throwing ropes from ship to ship in cases of accidents, may easily be understood from the methods which he employs for saving lives in shipwrecks. Mr. Thomas Cook's life-buoy is related to the same clase of inventions; its object is to preserve the life of a person falling overboard in the night by means of a floating light; and it obtained him a gold medal from the Society of Arts in 1818. He observes that a ship may often have to run half a mile before she can get about, and lower a boat ; so that it becomes highly desirable to afford a temporary support to the sufferer. The machine consists of two casks, with a pillar between them, carrying a composition of portfire, to be lighted by a lock when the accident happens, and to serve as a rendezvous to the man and the boat. He found that it might be lighted, and let down into the water in the short time of five seconds ; being always kept suspended in a proper manner between the cabin windows at the stern of the ship.

While speaking of the life-boat, it may be advisable to notice a method for the safe removal of such ships as have been driven on shore.

For this purpose empty casks are usually employed to float off the vessel, especially if she is small, and at the same time near the port to which it is proposed to conduct her. In other cases, the following method adopted by Mr. Barnard will answer.

" On January 1, 1779 (says Mr. Barnard), in a most dreadful storm, the York East Indiaman, of eight hundred tons, homeward bound, with a pepper cargo, parted her cables in Margate roads, and was driven on shore, within one hundred feet of the head and thirty feet of the side of the Margate pier, then drawing twenty-two feet six inches water, the flow of a good spring tide being only fourteen feet off that place.

" On the third of the same month I went down, as a ship-builder, to assist, as much as lay in my power, my worthy friend Sir Richard

Hotham, to whom the ship belonged. I found her perfectly upright, and her sheer (or side appearance) the same as when first built, but sunk to the twelve feet water-mark fore and aft in a bed of chalk mixed with a stiff blue clay, exactly the shape of her body below that draft of water; and from the rudder being torn from her as she struck coming on shore, and the violent agitation of the sea after her being there, her stern was so greatly injured as to admit free access thereto, which filled her for four days equal to the flow of the tide. Having fully informed myself of her situation and the flow of the spring-tides, and being clearly of opinion she might be again got off, I recommended, as the first necessary step, the immediate discharge of the cargo; and, in the progress of that business, I found the tide always flowed to the same height on the ship; and when the cargo was half discharged, and I knew the remaining part should not make her draw more than eighteen feet of water, and while I was observing the water at twenty-two feet six inches by the ship's marks, she instantly lifted to seventeen feet eight inches; the water and air being before excluded by her pressure on the clay, and the atmosphere acting upon her upper part equal to six hundred tons, which is the weight of water displaced at the differenee of these two draughts of water.

"The moment the ship lifted, I discovered she had received more damage than was at first apprehended, her leaks being such as filled her from four to eighteen feet water in an hour and a half. As nothing effectual was to be expected from pumping, several scuttles or holes in the ship's side were made, and valves fixed thereto, to draw off the water at the lowest ebb of the tide, to facilitate the discharge of the remaining part of the cargo; and, after many attempts, I succeeded in an external application of sheep skins sewed on a sail and thrust under the bottom, to stop the body of water from rushing so furiqusly into the ship. This business effected, moderate pumping enabled us to keep the ship to about six feet at low water, and by a vigourous effort we could bring the ship so light as (when the cargo should be all discharged) to be easily removed into deeper water. But as the external application might be disturbed by so doing, or totally removed by the agitation of the ship, it was absolutely necessary to provide some permanent security for the lives of those who were to navigate her to the river Thames. I then recommended as the cheapest, quickest, and most effectual plan, to lay a deck in the hold, as low as the water could be pumped to, framed so solidly and securely, and calked so tight, as to swim the ship independent of her own leaky bottom.

"Beams of fir timber twelve inches square were placed in the hold

under every lower deck beam in the ship, as low as the water would permit; these were in two pieces, for the conveniency of getting them down, and also for the better fixing them of an exact length, and well bolted together when in their places Over these were laid long Dantzic deals of two inches and half thick, well nailed and calked. Against the ship's side, all fore and aft, was well nailed a piece of fir twelve inches broad and six inches thick on the lower and three inches on the upper edge, to prevent the deck from rising at the side. Over the deck, at every beam, was laid a cross piece of fir timber six inches deep and twelve inches broad, reaching from the pillar of the hold to the ship's side, on which the shores were to be placed to resist the pressure of the water beneath. On each of these, and against the lower deck beam, at equal distances from the side and middle of the ship, was placed an upright shore, six inches by twelve, the lower end let two inches into the cross piece. From the foot of this shore to the ship's side, under the end of every lower deck beam, was placed a diagonal shore six inches by twelve, to ease the ship's deck of part of the strain by throwing it on the side. An upright shore of three inches by twelve, was placed from the end of every cross piece to the lower deck beams at the side, and one of three inches by twelve on the midship end of every cross piece to the lower deck beam, and nailed to the pillars in the hold. Two firm bulkheads or partitions were made as near the extremes of the ship as possible. The ceiling or inside plank of the ship was very securely calked up to the lower deck, and the whole formed a complete ship with a flat bottom within side, to swim the outside leaky one; and that bottom being depressed six feet below the external water, resisted the ship's weight above it equal to five hundred and eighty-one tons, and safely conveyed her to the dry-dock at Deptford."

Lieutenant Shuldham has suggested an improvement in the mode of ballasting vessels, which is especially adapted for packets and other vessels of dispatch. With regard to the principle, it may be necessary merely to observe, that for ages back it has been known to every school-boy, who has amused himself with sailing little boats, that they sail infinitely the best with their ballast fixed to their keels: the reason of which must be obvious to every mechanic; nevertheless to ballast sea-going vessels in the same manner by affixing to them lead or iron false keels, has generally been thought unsafe, as the centre of gravity would be so low as to occasion them to labour much in sea-way, an evil certainly very great. Now, in the application of such keels,

properly modified, to sea-going vessels, without being attended with the danger above-mentioned, consists the novelty of this invention; for, by an easy and convenient method of raising or lowering a certain weight for internal ballast, the centre of gravity can be altered as the judgment may direct, and adapted to any state of wind or sea;—thus, a vessel may, by a vast increase of stability, obtained by the centre of gravity being low, carry more sail than otherwise; which increase in the propelling power, would cause her to sail faster in proportion to its amount; the quantity of water she displaces being the same: this point, being so obvious, and having been practically proved, it will be unnecessary to enlarge on the subject.

The enclosed copy of a report respecting a boat, built under Lieut. Shuldham's inspection, at his Majesty's Dock-yard at Plymouth, will fully prove how well the plan, so far, practically answered. Its success induced the Lords Commissioners of the Admiralty to order it to be tried on the Quail cutter, to which vessel, however, it did not prove so decidedly beneficial, although her sailing qualities were thereby much improved; this arose from the form and dimensions of the Quail not being in unison with the plan, which is more suitable to a narrow vessel, and of such construction, that, without the aid of the lever of a heavy false keel, she would not have had sufficient stability.

The transom of Lieutenant Shuldham's boat being raised considerably higher than those of boats in general, her body is enabled thereby to be brought down in the water for sailing without dipping the same. Boats, as commonly built, when brought down, feel an inconvenience in proportion as the transom drags in the water; and how far the boat in question, or indeed any vessel with her transom raised so high, would answer in a sea, and in case of getting sternway in stays, we cannot speak to, not having seen the boat in such a situation (the water being smooth); but we should think there would be danger in the event of the boat getting sternway, from the transom being so high, and she so thin abaft.

We may observe, that this boat never lost her way in stays, and being decked flush with the gunwale, and having an iron keel of considerable weight brought to her deep wooden keel, so powerful a lever is created thereby, and by the internal weight of ballast, &c. as to enable her to carry a greater proportion of sail than any other boat of similar tonnage can possibly do; nor, if the well supported masts stand, is there the smallest danger of her upsetting, even when having some streaks of the deck in the water.

Ballast.

The following is the weight of the boat, &c.:

	Tons.	cwts.	qrs.	lbs.
Boat alone	2	2	0	12
Iron keel, bolts, &c.	1	3	1	9
Iron ballast	1	16	0	6
Lead ditto	0	14	0	14
Men, sails, rigging, stores, &c.	1	2	0	12
Total	6	17	2	25

length in the extreme 32 feet, and 30 in keel; and extreme breadth 8 feet: tonnage, by measurement, 10$\frac{81}{94}$ tons.

The plan of raising the ballast to the centre of gravity when going large, to prevent the boat from rolling, was found to have the desired effect, for after bearing up, when round the east end of the island, she rolled pretty quick and deep, until the ballast was raised, after which she proceeded as steadily as boats of her tonnage are accustomed to do in sailing.

But, notwithstanding the great superiority this boat had over the two which were tried with her, as well as over many others which have sailed against her, it might be recommended, that, in order to establish a judgment in respect to the plan on which she is fitted being calculated to answer general purposes, that one of the best sailing revenue cruizers be fitted for trial, against another of as nearly similar tonnage as can be, and, if possible, still better qualities, although the boat in question has answered beyond expectation.

Underneath is a statement of the particulars of the sails used in the principal yard boat, and in that of Lieutenant Shuldham's at the time of trial.

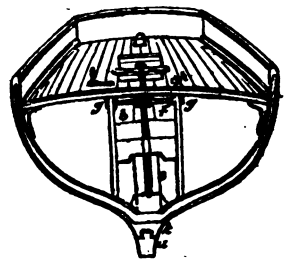
Lieutenant Shuldham's Boat.

Large jib	7$\frac{1}{4}$	7$\frac{1}{4}$	5$\frac{1}{2}$, 7	23 yards of canvass.	
Foresail	7	8$\frac{1}{2}$	8, 6	54$\frac{1}{2}$	Ditto.
Gaff topsail	7$\frac{1}{2}$		4$\frac{1}{2}$, 5$\frac{7}{8}$	19$\frac{1}{2}$	Ditto.
Mainsail	6$\frac{1}{2}$	8$\frac{3}{4}$	7$\frac{3}{4}$, 6	52$\frac{1}{2}$	Ditto.
Gaff topsail	7		4$\frac{1}{2}$, 5$\frac{1}{8}$	19	Ditto.
Mizen	4$\frac{1}{2}$	5	4$\frac{1}{8}$, 3$\frac{1}{2}$	14	Ditto.
			Total	182	

Twelve-oared Yard Cutter.

Jib	24$\frac{3}{4}$

Ballast.	
Foresail	30½
Mainsail } Sprit	40
Mizen }	13½
Total	108½



The figure is a sectional representation of a cutter. *a*, the fixed ballast of lead or cast iron, forming part of the false keel.

b, the moveable ballast, arranged in a box or frame transversing on a screw, and thus admitting of being raised or lowered at pleasure.

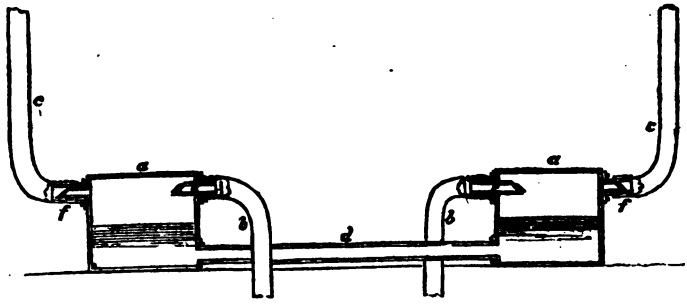
c, a screw, the threads of which form a close spiral and therefore capable of being managed by the capstan bars *d*.

e, a screw, the threads of which form a loose spiral, and therefore admits of much more rapid motion than the former, but requires for its due government the addition of a cog-wheel *f*, and pinions *g g*, together with the winch *h*.

With reference to *ventilation* Mr. Finlayson who has published a very admirable work on dry-rot, &c. very judiciously remarks, that in ventilating a ship we ought to have the following objects in view :— The supplying her with a current of pure air for the purpose of animal respiration ; and also to dry the decks and timbers.

Now the common windsails in this variable climate, cannot be used with advantage more than one day out of three ; and during the remainder of the time their operation will often be null, and sometimes even detrimental. But under all changes of weather, Dr. Hale's ventilators were useful in pumping out the vitiated air from the hold of a ship, while the atmospheric pressure supplied its place with that of a cold and pure quality ; by which means, the atmosphere of the lower deck, &c., could be renovated at pleasure. It ought also to be remarked here, that owing to air becoming specifically lighter by being heated, it will continue to ascend from the interior of a ship, through the different apertures, while its place will be supplied by colder air from the exterior. This, to a certain extent, is true, and in continual operation ; yet when we recollect the great quantity of carbonic acid gas which is thrown off by animal respiration during the night, and the proportion in which this ponderous air enters into chemical combination with the atmosphere, we are compelled to admit (from its

greater specific gravity) that holds and store-rooms will become the receptacles of this pestilential gas. But the evil does not end here, for fixed air furnishes a natural and luxurious nourishment for fungi, carbon being part of the food, and the base of all the vegetable kingdom. Indeed, this is a process which nature employs for the double purpose of nourishing plants, and renovating our atmosphere. Mr. F. goes on to say, " The method I would recommend for ventilating ships is as follows :—During the continuation of wind, and while there is considerable motion in a ship, the windsail now in use, and Mr. Perkins's ventilator, will answer the purpose most completely ; but when neither wind or motion is at hand, we must have recourse to manual strength and machinery to pump out the vitiated air, and the atmospheric pressure will supply its place with that of a cold and pure quality. The windsail and Mr. Perkins's ventilator will be best suited to sea-going ships ; while an engine for pumping out the foul air (after the manner of ventilating the Session House at the Old Bailey) will be better adapted for ships in ordinary, and guard ships, where the rolling is inconsiderable." Mr. Perkins's method of ventilating the hold of a ship will at once be understood by referring to the engraving, in which the



apparatus is shown ; *a*, being a tank or water-butt ; *b*, hose-pipe for conducting the foul air into the tank ; *c*, hose for conducting the foul air from the tanks; *d*, connecting water-pipe intended to pass to a similar apparatus on the other side of the vessel. There is a valve for admitting the foul air into the tank by the ascending pipe, and the valve, *f*, is placed to allow it to escape. The operation of this self-acting ventilator is as follows:—Each tank or butt is half filled with water, which flows freely from one to the other through the pipe *d*. The quantity of water running alternately from each depends upon the motion of the ship. When one of the tanks is elevated by the ship's

motion, the water will run through the pipe *d* into the depressed tank, and thereby discharge as much foul air through the valve *f*, as the additional water displaces. The elevated tank at the same time is receiving the foul air through the lower pipe and valve from the hold of the ship, to supply the vacuum that would otherwise be made by the escape of the water. If the tanks are fixed at right angles with the keel of the ship, the ventilator will operate only with the roll of it; but if placed diagonally, both the pitch and roll of the vessel will discharge the foul air. It would be most economical to fill the tanks at the beginning of the voyage. The first water for the ship's use should be taken from the ventilating tanks, leaving, however, half of it behind for operation. If the remaining water should ever be wanted for the ship's use it can be drawn off, and replaced by salt water. It will be seen that by this mode of ventilating, nothing but the hose and valves are to be added to what must necessarily be on board every ship.

A very ingenious contrivance for ascertaining the trim of a ship has been suggested by Mr. Perkins, it consists of two instruments called an *Orthometer* and a *Pleometer*, and as the construction of both these instruments is the same, differing only in the relative proportion of the parts, one description will serve for both. The instrument is in fact a mercurial level, consisting of a horizontal tube turned up vertically at each end, to the height of about three inches. This tube or syphon is filled with mercury, so that the fluid rises up about an inch in the two legs, to each of which a float is fixed, forming one end of a lever, as the index does the other end, which is so adjusted, that the two indexes are in the same horizontal line when the mercury stands at the same height in both the legs; but when the mercury is unequal, then the indexes are, the one higher and the other as much lower than the horizontal line. Two instruments of this kind being fixed against the side of a ship's cabin, one in the same line with the keel, and the other at right angles to it, will show by changes in the relative position of the indexes, the angular changes in the position of the ship itself, occasioned either by the distribution of the cargo, or by the impulse of the wind on the sails.

The instrument is suspended by two points, one of which is fixed; the other is capable of being raised or lowered by an adjusting screw. As however, from the pitching and rolling of the ship, the mercury would be in a state of constant and violent oscillation, so as to render any accurate observations impossible, the inventor has obviated this difficulty by fixing a perforated screw upon the middle point of the horizontal part of the tube, by means of which the bore in that part can

be diminished to any required degree, so as to render the instrument insensible to individual and sudden changes in the position of the ship, while it continues to indicate the average inclination of the vessel.

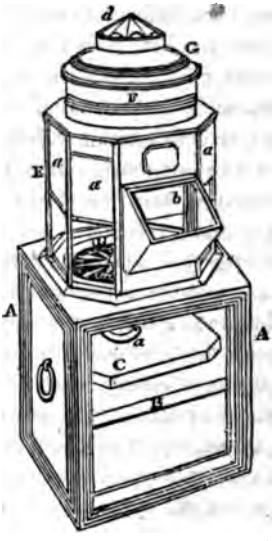
When the vessel is at sea, and sailing to the most advantage, the adjusting screw of the instrument is to be turned till the two indexes are brought into the same horizontal line, and this adjustment will ever after continue to indicate the trim of the vessel, as long as no material change in the quantity and position of the cargo takes place. Hence, by mere inspection of the instruments so adjusted, the master will know whenever his ship is, or is not, sailing to the most advantage.

The instrument placed in a line with the keel of the ship is denominated by Mr. Perkins an Orthometer, that placed at right angles to the keel a Pleometer.

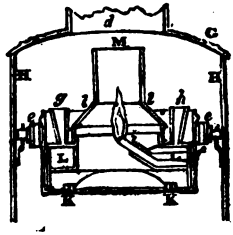
The binnacle, or box which contains the compass, in ordinary ships, is a very imperfect and inaccurate contrivance; it is a box situated upon the deck, with a partition, dividing it into two chambers, one for containing a lamp or candle, and the other for the compass-box; the partition having a pane of glass in it to admit the light upon it, and the front of the division, where the compass is kept, has also a window to see into it. The compass-box is generally made of wood, and square, containing within it a circular brass box, suspended on gimbals, and in this is the compass card; its points are read against a mark, usually made by a pencil, within side the brass box, and called *Lubber's Mark.* A line drawn from this to the centre of the compass card, should, in all cases, be exactly parallel to the line of the ship's keel, otherwise her course by the compass will never be correct, the manner in which the compass-box is fitted into the binnacle, renders this very uncertain, for the square box being smaller than the inside of the binnacle, wedges are driven in all round to make it fast; but there is nothing to make it certainly parallel to the ship's keel. The binnacle is frequently made with three divisions instead of two, then a compass is placed in each side, and the light in the division between them; but, unless the binnacle is very large, there is an objection to placing two needles so near together, as they are liable to act upon each other. The light is very imperfectly thrown upon the compass card in the common way, and may also be seen at a distance from the ship.

The binnacle invented by Mr. Grant Preston has a cylindrical top, which incloses the lamp in a case, being on that account convenient for lighting below in case of bad weather, which convenience has been long wanted by mariners; the body and upper part of this case being made of copper, renders them very durable and compact. The lamp gives a

powerful light vertically on the compass; is simple in its construction, steady in its burning, and the expense of the oil small; no light is seen to dazzle the eye of the man at the wheel or tiller, nor is any light shewn which can be seen by the enemy at sea.



A A, in the accompanying figure, is a square box, closed by a door in front, which is omitted in the figure, to shew the interior. This box is fixed down, in a proper situation, on the deck, and supported at a height favourable to view the compass-card which it contains; the two sides being exactly parallel to the ship's keel. *B*, is a shelf in the box, to support a board *C*, which exactly fits the box, but has its angles taken off to permit it to slide in and out more freely; it has a stem, *a*, of brass wire standing up from the centre of it, and terminating in a sharp point, on which the compass-card is freely suspended to turn round; being then included within a circular opening made through the top of the box, and its divisions reading against a line drawn on a piece of white paper seen plainly in the figure. The opening in the top of the box is surrounded by an octagonal lantern *E*, which has glass panes in all its sides, half way up from the bottom, to admit light in the day time, but at night these are closed by sliding shutters *a a a*. The compass is seen through the glass *b*, which is placed at a proper inclination to command the view of the card; the lamp is situated in a circular box, fitted into a ring *F*, at the top of the lantern-frame; and has a dome *G*, with a chimney *d*, to take off the smoke. The section annexed will explain the interior parts, *H H* are the sides of the cylindrical box, which fits into the ring *F*; *e e* and *f f*, are the sections of two brass circles, called the gimbals; the external one has two projecting points, which are received in pieces of copper soldered to the inside of the box; the internal ring has similar pivots, but these are received into holes in the outer ring, the direction of



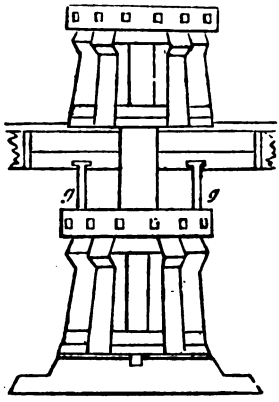
of the two lines of pivots being at right angles to each other, hence the interior ring, and all which it supports, has an universal motion, and if properly balanced, will preserve its horizontal position in any inclination of the box. There is a brass box, which fits into the ring *F*, and has in the bottom of it a large plane convex lens *K K*, which concentrates the light of the lamp above, and throws it down upon the card beneath. The lamp *L L*, is just within the box: it consists of a deep copper hoop, forming the external surface; a lid at the top, and a bottom half way down, which have each a large hole through their centres, and therefore be considered as rings; another hoop being soldered within these rings, forms a complete hollow ring, in which the oil is contained, being filled at two tubes *g h*. The wick *i* is situated in a kind of spout, which proceeds from the interior of the ring to its centre; and, being very narrow, diminishes very little of the light; for, as shewn in the figures, the flame is caused to project over the end of it, and then comes in the centre of the whole, that the lens *K K* may throw the light down with the greatest effect; and to increase this, a reflector is added. This is a kind of conical chimney, *l l*, which stands over the lamp, and includes the light; the conical part, *L L*, of this, is tinned within side, and well polished, to reflect the light downwards. By this means the card is always well illuminated, and if the shutters *a a*, are put down, no light is shewn which could be perceived by an enemy at sea, for the only aperture *b* directs the light upwards, and that in a direction where it will not fall upon any part of the ship.

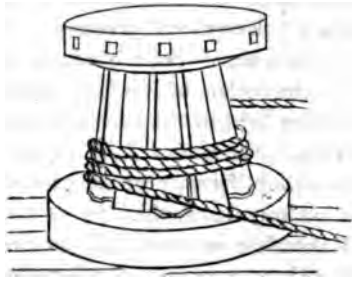
There are, as we have already had occasion to state, commonly two capstans in a large ship; the main capstan placed behind the main mast, standing on the first deck, and reaching four or five feet above the second: this is also called the double-capstan, because it has two drum-heads, and serves two decks for drawing of anchors; and because its force may be doubled by applying hands on each deck. It has bars, whelps, &c., for turning and stopping it. The other is the jeer-capstan, or little-capstan: this stands on the second deck, between the main mast and the mizen: its use is; chiefly, to heave upon the jeer rope, or to heave upon the viol, to hold off by when the anchor is weighed; and on other occasions where a less force is required, than to weigh the anchors, &c.

The French call that an English capstan where there are only half bars used: and which, for that reason, is only half perforated: this is thicker than the other.

There is also a flying-capstan, which may be moved from place to place.

Capstan.





The parts of a capstan are, the foot, which is the lowest part; the spindle, the smallest part of which turns round in an iron socket, called the saucer; the whelps, a sort of brackets set into the body of the capstan close under the bars, and reaching downwards from the lower part of the drum-head to the deck; the barrel, the drum-head, which is a broad cylindric piece of wood fixed above the barrel and whelps, in which are the holes for the bars to be put into; the bars, which are small pieces of timber by which the men heave; the pins, which are little bolts of iron, thrust perpendicularly through the holes of the drum-head; and through a correspondent hole in the end of the bar, made to receive them when the bars are fixed; the pawls, which are pieces of iron bolted to one end of the beams of the deck, close to the body of the capstan, but so as that it have liberty to turn about every way; and against them the whelps of the capstan bear; so as that by them the capstan may be stopped from turning back. There are also hanging pawls, as *g*, *g*, which reach from the deck above to the drum-head immediately beneath it; and lastly, the swifter, which is a rope passed horizontally through holes in the outer ends of the bars and drawn tight, designed to keep the men steady whilst they work, and to afford room for a greater number to work at once.

An important improvement has lately been proposed for the capstan by Capt. Hamilton, of the Royal Navy, which is that of reducing the number of whelps from six to five, making the lower part more obtuse, and filling it up circular by the chocks, and also making the upper part more perpendicular in the sides, and open, the whelps being a portion of a circle.

Several minor improvements have also been effected, which chiefly consist in substituting iron for the more perishable materials previously employed.

Cables.

The cable and anchor will conclude our notice of this important subject. Every merchant vessel, how small soever, has three cables, viz., the main or master cable, which is that of the chief anchor, called the sheet-cable; and the two bowers, best and small. The ordinary length of the great cable is 120 fathoms or braces.

To make a cable:—after forming the strands, they use a machine, which they first pass between the strands that they may turn the better and be intertwisted the more regularly together. And to prevent any entangling, a weight is hung at the end of each strand. The cable, being properly twisted, neither too much, so as to become stiff, nor too little, so as to be weakened, is untwisted again three or four turns, that the rest may the better retain its state. The usual allowance for the diminution of length by twisting, is one-third of the whole; so that for a cable of 120 fathoms, the rope yarn must be 180 fathoms long.

The number of threads which each kind of cable is to be composed of, is always proportioned to its length and thickness; and it is by this number of threads that its weight and value are ascertained. Supposing, then, the lengths, to be equal, the number of threads and the weights will be as the areas of their bases, or, which comes to the same, as the squares of their circumferences. Having then the weight and number of threads of any one cable, we may easily calculate the following table.

Circumference.	Threads.	Weight.
3 Inches	48	192 Pounds.
4	77	308
5	121	484
6	174	696
7	238	952
8	311	1244
9	393	1572
10	485	1940
11	598	2392
12	699	2796
13	821	3284
14	952	3808
15	1093	4372
16	1244	4976
17	1404	5616
18	1575	6296
19	1754	7016
20	1943	7772

Cable.

A Table, shewing how many fathoms, feet, and inches of rope of any size, under fourteen inches, makes a hundred weight, with the use of the table.

Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.	Inches.	Fathoms.	Feet.	Inches.
1	486	0	0	4 1/32	24	0	0	8	7	3	6	11 1/32	3	4	1
1 1/16	313	13	0	4 3/32	21	3	0	8 1/32	7	0	8	11 3/32	3	3	3
1 3/32	216	0	0	5	19	3	0	8 3/32	6	4	3	12	3	2	3
1 1/8	159	3	0	5 1/32	17	4	0	8 1/8	6	2	1	12 1/32	3	2	1
2	124	3	0	5 1/16	16	1	0	9	6	0	0	12 1/16	3	2	0
2 1/16	96	2	0	5 3/32	14	4	6	9 1/32	5	4	0	12 3/32	2	7	8
2 1/8	77	3	0	6	13	3	0	9 1/16	5	2	0	13	2	5	3
2 3/16	65	4	0	6 1/32	12	2	0	9 3/32	5	0	6	13 1/32	2	4	9
3	54	0	0	6 1/16	11	3	0	10	4	5	0	13 1/16	2	4	0
3 1/16	45	5	2	6 3/32	10	4	0	10 1/32	4	4	1	13 3/32	2	3	6
3 1/8	39	3	0	7	9	5	6	10 1/16	4	2	2	14	2	2	1
3 3/16	34	3	9	7 1/32	9	1	6	10 3/32	4	1	8				
4	30	1	6	7 1/16	8	4	0	11	4	0	3				
4 1/32	26	5	3	7 3/32	8	3	6	11 1/32	3	5	7				

If we want to know how much of eight-inch and quarter rope will make an hundred weight? Find 8 1/4 under inches, and against it, in the sixth column, occurs 7, 0, 8, which shews in a rope of 8 1/4 inches, there will be seven fathoms eight inches required to make one hundred weight.

A Table, shewing the weight of any cable or rope of 120 fathoms in length, and for every half inch from three inches to twenty-four in circumference.

Inches.	Cwts.	Qrs.	Inches.	Qrs.	Cwts.	Inches.	Cwts.	Qrs.	Inches.	Cwts.	Qrs.	Inches.	Cwts.	Qrs.
3	2	1	7 1/2	14	0	12	36	0	16 1/2	68	0	21	110	1
3 1/2	4	0	8	16	0	12 1/2	39	0	17	72	1	21 1/2	115	2
4	4	1	8 1/2	18	0	13	42	1	17 1/2	76	2	22	121	0
4 1/2	5	0	9	20	1	13 1/2	45	7	18	81	0	22 1/2	126	2
5	5	1	9 1/2	22	2	14	49	0	18 1/2	85	2	23	132	1
5 1/2	7	0	10	25	0	14 1/2	52	2	19	90	1	23 1/2	138	0
6	9	0	10 1/2	27	2	15	56	1	19 1/2	95	0	24	144	0
6 1/2	10	2	11	30	1	15 1/2	60	0	20	100	0			
7	10	1	11 1/2	33	0	16	64	0	20 1/2	105	0			

Cable.

Link worming of a cable is an operation performed for preserving it in rocky and stony ground, or defending it against ice. For this purpose chains are twisted round cables in the following manner. Take three chains, each about 15 fathoms in length, and all of an equal size, and in thickness proportioned to the purpose to which they are adapted. Let those be wound round the cable, so that they may project sufficient to sustain the greatest part of the friction, one end of them being fastened to the ring of the anchor, and each chain being from thence wormed round its respective hollow or channel of the cable, so as not to prevent its stretching. Fasten the other ends of the chain to the cable. The chains need not be very heavy; but the links should be short, because they will thus be more pliant, and worm more easily. These chains will effectually guard against the chafing of the rocks, and they may be put on in a few minutes, so that it is not necessary to have them fitted on, but when they are likely to be serviceable. As the weight of the three chains, even for a large cable, will not exceed 500 pounds, the only remaining difficulty is that which arises from the smallness of the hawse holes; in order to obviate this, the holes may be enlarged; and with the additional aid of a boy or spare man at the head of the vessel, to cast off the chains as they come up, and hand them in above, every inconvenience will be removed. But if it should require a few minutes more to weigh an anchor so secured, than a common one, this can be no argument against a measure that tends to preserve and ensure the safety of the vessel and of the ship's company. In high latitudes, where ice may cut or damage the cables, while riding at anchor, the use of three other chains such as the preceding, but not more than five or six fathoms in length, may be recommended.

It may be hardly necessary to state that the general use of chain cables has much diminished the necessity for resorting to this ingenious contrivance.

The anchor of the vessel will now claim our attention. Those that are now made, are so contrived as to sink into the ground as soon as they reach it, and to hold a great strain before they can be loosened or dislodged from their station. The parts of which an anchor is composed, are the ring, into which the cable is fastened; the beam, or shank, which is the longest part of the anchor; the two arms, at the ends of which are the two flukes, or flooks, by some called the palms, which, with their barbs, fasten into the ground; and the stock, which is a long piece of wood, fastened across the beam near the ring,

and serving to guide the flukes in a direction perpendicular to the surface of the ground, so that one of them sinks into it by its own weight as soon as it falls, and is still preserved steadily in that position by the stock, which, together with the shank, lies flat on the bottom. In this situation it must necessarily sustain a great effort before it can be dragged through the earth horizontally: this, indeed, can only be effected by the wind or tide, or by both of them; the effect of which is sometimes increased by the turbulency of the sea, and acts upon the ship so as to stretch the cable to its utmost tension, and may thus dislodge the anchor from its bed, especially if the ground be soft and oozy, or rocky. When the anchor is thus displaced, it is said, in the sea-phrase, " to come home."

The several parts of the anchor, above enumerated, bear the following proportions. The length of the arm, from the inside of the throat to the bill, is the distance marked on the shank for the trend, taken from the inside of the throat; and three times that is the length of the shank, from the tip of the crown: and the shank, from the tip of the crown to the centre of the ring, is the length of the iron stock. When made, the two arms, from the inside of the throat to the extremity of the bill, should form an arc of a circle, containing 120 degrees.

Of anchors, there are the sheet, best bower, small bower, and spare anchor: these do not vary in form or weight from each other in the navy. Stream and kedge anchors are smaller, and grapnels are only for boats. Ships of 110, 100, 98, and 90 guns, have seven anchors; from 80 to 20 guns, inclusive, six anchors; ships of 300 tons, and sloops, have five; and brigs and cutters three anchors.

The goodness of the anchor is a point of great importance; the safety and preservation of the vessel depending principally upon it. The shank, arms, and flukes, are first forged separately; then the hole is made at one end of the shank for the ring, which, being also previously forged, is put into the hole of the shank, and the two ends shut together. After which, the arms are shut to the shank, one after the other, and the anchor is finished.

The shank is made of many long bars of the best tough iron well wrought together: and great care should be taken, that the iron be neither too soft nor too brittle; the latter rendering it too liable to break, and the former to straighten. The number of bars sufficient to make the shank of the intended size, must be regulated by experience. Several parts of the anchor are governed by the size of the trend, which is marked on the shank at the same distance from the inside of the throat, as the arm measures from the inside of the throat

to the extremity of the bill. The shank is rounded to the square of the upper part, and is there called the small round, being the smallest part. The two sides, in the direction of the arms, are flatted surfaces, about an inch less than the trend in large anchors, and something less in smaller ones. The squared part is of the same size as at the trend each way, and hanches into the small round, one-sixth of the length of the shank. The hole, or eye, for the ring, is punched through the square part, or the flatted side, once and a half the thickness of the ring, from the upper extremity of the shank, which has its corners flatted, or diamonded, on the same sides, nearly in the middle. Between the hole for the ring and the lower part of the square, are two small prominencies, raised across from the solid, called nuts, for securing the stock in its place. At the lower part of the shank is left a scarf, or flatted surface, with a shoulder on each side, for shutting on the arms.

In making every part of an anchor, the nicest attention should be observed, as to its being smooth, fair, and even; and that the edges and angles be preserved straight in their direction; as well-made anchors should possess beauty as well as strength. The ring, being previously forged, is put through the fore-mentioned hold in the shank, and the two ends are well shut together. The arms are made of shorter bars than the shank, but as good in quality, and as well put together; they are rounded and flatted on the different sides, to resemble the shank, and are of the same size as the shank at the throat and the small round. The rounding part is continued to the palm, which is nearly in the middle of the arm; from thence it is made with a square, tapering to the bill on the flatted side; and, on the inner rounded side, is made a square seat for shutting on the palm, that the palm, when shut on, should project its thickness at the base, or inner part, the outer part making a straight surface with the peak, or bill. The back, or outer side of the arm, is made straight from the rounded part, or hanch, to the snape, and there kept to half the substance of the inner part. The snape resembles the bill of a duck, and is one-third the breadth of the palm in length. The thickness of the ring is to be half the diameter of the small round: the diameter of the ring, including the thickness, reaches from the hole in the upper part of the shank, to the hanch of the small round. The inner part of the arm is mostly made straight from the bill to the throat; and it is thought stronger for having a small angle in its length, inclining to the shank. Shanks taper in their length, one and one-half inch in small anchors, to three inches in large, keeping their proper size at

the trend; and three-fourths of an inch to two inches in the flatted way. The arm, in its length, inclines to the shank, and forms a small angle, the touch or point thereof being in the middle. The throat-end of the arm is scarfed, or flatted, to answer the scarf in the shank, to which the two arms are united (after the palms are shut on) in the firmest manner possible; and it is elevated above the horizontal plane, or inclined to the shank, that each arm may spread at the peak or bill. The length of the arm, from the inside of the throat to the extremity of its bill, is then taken; and that length, from the inside of the throat, is set upon the shank, and called the trend: from the trend to the bill is formed an angle of about sixty degrees. The palms, or flukes, are two thick plates of iron, made of various pieces, well wrought together, in the form of an isosceles triangle, one and one-half inch to one and one-fourth inch longer than the breadth of the base, and curve about as much in their sides. The base, or lower part, is to be straight; the inner flat surface curves a little in the breadth, but is straight lengthways; the palms being finished thus far, are lastly shut firmly into the inner side of the arm, in the seat before mentioned, the base inclining inwards.

The stock is composed of two long beams of oak, strongly bolted and tree-nailed together, and secured with four strong iron hoops, two on each side of the middle, and one near each end. It is fixed on the upper end of the shank, transversely with the flukes or palms; and the nuts are let into the middle of the stock. The length of the stock is the length of the shank and half the diameter of the ring; the depth and thickness in the middle are as many inches as the stock is feet in length. The ends are to be kept square, half the depth or thickness in the middle. The upper side, next the ring, is always kept straight; as is the lower side half the depth on each side of the middle; and thence it tapers to each end in the above proportion. It is necessary to leave an opening in the middle of one and one-half inch between the two pieces, that the hoops may be driven nearer the middle, in case the stock should shrink.

Proof is made of anchors, by raising them to a great height and then letting them fall again on a kind of iron block, placed across for the purpose. To try whether the flukes will turn to the bottom and take hold of the ground, they place the anchor on an even surface, with the end of one of the flukes, and one of the ends of the stock resting on the surface; in case the anchor turns, and the point of the fluke rises upwards, the anchor is good.

For the proportions of anchors, according to Manwaring, the shank

is to be thrice the length of one of the flukes, and half the length of the beam. According to Aubin, the length of the anchor is to be four-tenths of the greatest breadth of the ship; so that the shank, *e. g.* of an anchor in a vessel thirty feet wide, is to be twelve feet long. When the shank is, for instance, eight feet long, the two arms are to be seven feet long, measuring them according to their curvature. As to the degree of curvture given the arms, there is no rule for it; the workmen are here left to their own discretion.

Aubin, in his Marine Dictionary, gives a table from a Flemish writer, wherein the lengths of the shanks of anchors for vessels of all widths, is computed, as well as the weights of the anchors, from a vessel eight feet wide within, which requires an anchor three and one-half feet long, weighing thirty-three pounds, to a vessel forty-five feet wide, which demands an anchor eighteen feet long, and weighing 5832 pounds. He likewise observes, that the anchor of a large heavy vessel is smaller, in proportion, than that of a lesser and lighter one. The reason he gives is, that though the sea employs an equal force against a small vessel as against a great one, supposing the extent of wood upon which the water acts to be equal in both, yet the little vessel, by reason of its superior lightness, does not make so much resistance as the greater; the defect whereof must be supplied by the weight of the anchor.

The making of anchors is a most laborious employ, and has been much facilitated by the invention of two machines, called, the Hercules and the Monkey. The Hercules is used for setting straight the shank, welding the palms to the arms, and the arms to the shank, of large anchors. It consists of a weight of about 400 lbs. faced with steel, and a long iron shank. It is suspended perpendicularly over the work by a rope encircling a small iron wheel fixed in a mortise cut in the beam.

It performs its duty by being drawn up about seven feet high, by men at the tails of the rope; and, increasing in weight by the velocity of its fall, it is found to produce more effect than the most powerful exertions with the hammer and strength of man. That the weight may fall on the spot required, a long iron rod, with a hook, is occasionally fixed to the shank above the weight, for the workman to direct the stroke.

The Monkey is a machine for setting the arms, &c. It consists of a weight of about 200 lbs., sometimes faced with steel, and a long iron shank suspended by an iron chain to a crane, hanging horizontally against the side of the work, and it is used by being drawn back and thrust forward by the workmen.

Anchor.

The Number of Anchors allowed each Ship in the Royal Navy, with their Weight and Value.

S. stands for Stream—K. for Kedge.

No.	*110 & 100 Guns.*		*Value.*		*No.*	*96 & 90 Guns.*		*Value.*		*No.*	*80 & 74 Guns.*		*Value.*		*No.*	*Smaller 74 Guns.*		*Value.*		*No.*	*64 Guns.*		*Value.*	
	cwt.	*qr.*	£.	*s.*		*cwt.*	*qr.*	£.	*s.*		*cwt.*	*qr.*	£.	*s.*		*cwt.*	*qr.*	£.	*s.*		*cwt.*	*qr.*	£.	*s.*
5	81	0	1215	0	5	73	0	1003	15	4	71	0	781	0	4	67	0	670	0	4	57	0	502	2
S. 1	21	0	32	11	S. 1	18	0	27	0	S 1	17	2	26	0	S. 1	16	0	24	0	S. 1	15	0	22	10
K. 1	10	2	15	15	K. 1	9	0	13	10	K. 1	2	2	12	10	K. 1	8	0	12	0	K. 1	7	2	11	0

No.	*60 Guns.*		*Value.*		*No.*	*50 Guns.*		*Value.*		*No.*	*44 & 38 Guns.*		*Value.*		*No.*	*36 Guns.*		*Value.*		*No.*	*32 Guns.*		*Value.*	
4	53	0	437	17	4	49	0	382	4	4	40	0	272	0	4	39	0	240	16	4	33	0	210	4
S. 1	12	0	18	0	S. 1	11	0	16	10	S. 1	10	0	15	0	S.	9	0	13	10	S. 1	8	1	12	5
K. 1	6	0	9	0	K. 1	5	2	8	0	K. 1	5	0	7	10	K. 1	4	2	6	10	K. 1	4	0	6	0

No.	*28 Guns.*		*Value.*		*No.*	*24 & 20 Guns.*		*Value.*		*No.*	*14 Guns, 300 Tons.*		*Value.*		*No.*	*Sloops, 200 Tons*		*Value.*		*No.*	*Brigs, 200 Tons*		*Value.*	
						29	2	180	11	6														
4	31	0	198	8	4	25	0	155	0	0	3	20	0	93	0	3	15	0	67	10	3	12	0	54	0
S. 1	8	0	12	0	S. 1	7	2	11	0	0	S. 1	7	0	10	10	S. 1	6	0	9	0		*Cutter.*			
K. 1	4	0	6	0	K. 1	3	2	5	0	0	K. 1	3	2	5	0	K. 1	3	0	4	10	3	10	0	45	0

Dry Rot.

A few observations on that very important subject, the dry rot will not be out of place, as its ravages have done more towards the destruction of our navy than all the efforts of hostile fleets.

Whatever may be the immediate cause of the dry-rot, the principle of vegetation brought into activity has, at least, a considerable share in it. The natural juices of the oak—call them sap, or distinguish them by their constituent parts, gallic acid, mucillage, tannin, and whatever else may enter there—are in a different state, and in different proportions, at different seasons of the year; being more abundant and in a state of greater fluidity in the spring and summer than in winter: hence the idea of the sap rising in the spring, being stationary in the summer, and falling in the winter; but the question is, falling whither, and rising from whence? The sounder opinion is, that the genial warmth of the spring dissolves and puts into motion the juices of the tree already residing in the trunk and branches (as is evident from the pushing of leaves, in the spring, out of the trunk of a tree which had been felled the preceding winter);—that it sends them to the extremities to form new leaves, flowers, and fruits; and that, having performed these offices, the residue becomes dense and gross, is formed into a layer of new wood, or alburnum, which, in its turn, together with its elder brethren, or former layers, elaborate, during the apparent quiescent state of the tree, a new supply of sap or juices for the succeeding year; while the vessels of the older layers near the centre are closing and collapsing, till the wood there becomes one solid mass, and is known as the heart of the tree.

It is either in the sap vessels of the alburnum, or in the surface of the tree, immediately beneath the bark, that the appearance of the dry-rot first discovers itself in recticulated filaments; sometimes between the concentric layers of the alburnum, at other times spreading over the surface. If suffered to proceed, the insterstices of these filaments are soon filled up, and a complete leather-like fungus (*xylostroma giganteum*) is formed, being that particular genus of this parasitic family which chiefly infests the oak, though another genus (*boletus*) is not uncommon in ships: that which mostly infests the lower parts of houses is the *boletus lachrymans*, which is peculiar to fir. The production of the gigantic fungus can only take place after the tree has been cut down; for although fungi of different kinds are frequently found growing in decayed parts of trees, yet a sound part is never affected with the least symptom of dry-rot, so long as the vital principle of the juices keeps them in a state of activity. It would seem, indeed, that the process of fermentation is almost necessary for the growth of many of the fungi: the 'mushroom spawn,'

for instance, is well known to gardeners to be easily generated from the seeds eaten by a horse; and the future plant as easily devoloped by some process of fermentation which it undergoes in the dung. Thus also wood, in a state of decomposition, is found to be favourable for the reproduction of fungus from seeds; but while the former is furnishing food for the support of the latter, this parasite is, in its turn, exhausting what remains of the gaseous and soluble products of the base upon which it was fastened.

But though the appearance of fungus is generally an accompaniment of dry-rot, its presence is not essentially necessary to constitute that disease. The wood will not rot without the plant; but the seeds of these parasites are so minute and multitudinous, and are supposed to be so widely floating about invisibly in the air as to lodge upon every tree and plant above the surface of the soil: fortunately, however, they seem to require the aid of putrefactive fermentation to enable them to germinate; were it otherwise, and but a ten-millionth part of them grew, our earth would be a world of mushrooms; instead of which, they either perish or lie dormant, apparently for centuries without vegetating. This, however, is nothing more than happens to crops of white clover, which spring up on the application of lime to dry heaths and barren soils; or of raspberry bushes, which start up where fir woods have been burnt down, though not a vestige of either had appeared there before. We should say, generally, that where fungi make their appearance on the surface of timber, the dry-rot is commencing externally, and would in time destroy the mass on which the parasite had fixed its roots; but it may also consume internally without any indication of fungi, where the putrefactive process of the juices has taken place, in consequence of a heated, stagnant, and moist atmosphere. We find this perpetually occurring in the underground floors and apartments of houses, especially where fires are kept, and which thus become so many artificial hot-houses.

On the same principle may be explained the different durability of merchant ships, according to the nature of the trade in which they have been employed. Thus a new ship, built of green timber, and sent to Petersburgh for a cargo of hemp, will become completely rotten in a couple of voyages; while the same ship, if employed in carrying coal or lime would probably last half a century.

Without entering into any lengthened discussion, as to the origin of the dry-rot, we may proceed to examine the remedy which most obviously presents itself. It is simply that of getting rid of the native juices of the timber by whatever mode appears the most effective—

whether by impregnation with foreign substances, natural or artificial desiccation, or immersion in sand, mud, or water.

Common sea salt, a solution of corrosive sublimate, of sulphate of iron, or copperas, of alum, or, in short, saline substances of any kind, seem to be efficacious in preventing the putrefactive process in the juices of timber. The different resins and oils appear to answer the same purpose. Ships employed in the whale fishery are not liable to rot where the oil has penetrated the planks. The Dutch, from observing that their herring brushes were not subject to rot, adopted the practice of salting the timber and planks of their larger vessels, as did the Americans, from a similar observation with regard to the vessels employed in carrying out salt for their fisheries.

But as all impregnations of timber are either expensive or inconveniently performed, the most effective, simple, and at the same time, perhaps, the least injurious to the timber, is desiccation, either by a gentle heat, or in the natural way: the latter is unquestionably preferable, and if left exposed to a free circulation of air, in a dry atmosphere, and preserved from moisture, the largest piece of oak, in the course of three years, will have sufficiently parted with its juices to secure it from decomposition, and consequently from the dry-rot.

Immersion in sand, mud, or water, will preserve timber for centuries: exclusion from air and moisture appears to have the same effect. Instances have been found of the former in the piles of London bridge, which have existed 600 years; in those of the old Savoy, about the same length of time; in the wood of peat mosses, &c.; and of the latter, in the wooden figures found in the catacombs of Egypt, the mummy cases, and in the beautiful chestnut roof of Westminster hall.

The means of prevention, therefore, are sufficiently obvious: there can be no cure if the disease has proceeded so far as to decompose the wood and destroy the fibres. The measures adopted in the dock-yards, are long seasoning under sheds, the separation of the logs from each other by wedges, so as to admit a thorough circulation of air; or, immersion in salt-water, which has been found to answer the purpose beyond all expectation.

By a strict adherence to these precautions, which we have enumerated, and by the unremitting care which is subsequently taken of ships when in ordinary, by the officers of the dockyard, we may venture to repeat the Comptroller's assertion, that at no period of our history had England a navy, either for numbers or efficiency, at all equal to that which we now possess, and that the dry rot was never less destructive than at the present period.

A

GLOSSARY OF TERMS

CONNECTED WITH THE PRACTICE OF

SHIP BUILDING.

Apron, pieces of timber fayed to the after part of the stern, from the head down to the dead woop, the scarfs being generally about one foot long, moulded nearly the same scantling as the knight-heads; above the upper deck it might be moulded sufficient for the planks on each side to butt against. When the rabbet of the stem is at the aft part, the apron is frequently sided more than the stem, in order to receive the fastening of the fore-hoods; but as the fastenings must be all drove nearly in one direction, it is liable to split the apron, and therefore it is much stronger when the rabbet of the stem is in the middle, because then the apron is sided the same as the stem, and the knight-heads are fayed close to the stem and apron (except an opening for air is left) and bolted through the stem and apron, then the butt-end belts are drove into the knight-heads, which are broad enough to admit of their being cross-bored, and thus secures the butts of the fore-hoods much better than when they are fastened to the apron. The apron is intended to strengthen the stem, and therefore should butt clear of the scarfs of the stem and stemson.

Beams, pieces of timber placed across the ship on the clamps, and fayed to the timbers, except the platform-beams, and some of the after-beams of the lower deck; which, if they were to run close to the timbers would either require the clamps to sny very much, or else to be cut off, which would not be so strong, as to let the aft part of the clamps have an easy flight, and to let some of the after-beams and knees be fayed to the planks, as is the customary practice. The beams of the gun-decks are generally disposed to be under the ports, if possible, the better to support the gun. The ends of those beams that will admit of it are less broader at the ends, and from thence to the ends of the knees made straight, at which place the beam has its proper scantling. This is done to make the lodging-knee more without square, and therefore must be disposed at the same side of the beam. If the beams are in one piece, every other may be disposed with the butt-end

the same way, because the butts will decay before the tops.—Those beams that are made in two or three pieces are allowed to be as strong as those in one piece. When the beams are in two pieces, the scarf may be one-third of the length; if the beams are not very long, twelve feet is allowed sufficient for the scarf of any beam, and if the beams are in three pieces, the middle piece may be half the length of the beam. The length of the tablings may be about one-half more than the depth of the beam.—The most customary way of putting beams together, is to divide the tablings in the middle of the beam, and that part which is taken out at the upper side to be left at the lower side; when done in this manner (especially when kersey or flannel is put in the scarfs) the water is liable to lay in the scarfs, and must be the means of rotting the beams; therefore, to prevent that, if the beams were tabled together in dove-tails, and taken through from side to side putting tar only between them, which hardens the wood, the water occasioned by the leaking of the decks would have a free passage, and the beam would dry again.

Binding-strakes, are generally two strakes wrought near the comings; they are worked all fore and aft, about one inch or one inch and a half thicker than the rest of the deck, and let down between the beams and ledges, so that the upper side is even with the rest of the deck. The original design of them was to connect the deck so well together, as to prevent its drawing. The ship's decks have such a connection, that they seldom fail, but at the extremes, which cannot be secured too well. The butts in the middle of the decks may sometimes be perceived to strain, but that is occasioned by the ship's taking the ground, or straining by accident, which cannot be prevented by the binding-strakes, as performed in the common course of working, and therefore it consumes thicker stuff than is required. Those strakes in which the stopper-bolts are drove, might be English plank, and let down between the beams and ledges, if thought necessary.

Bitts, large pieces of straight timber to which the cables are fastened, likewise smaller pieces fixed near the masts, either on the upper-deck, quarter-deck, forecastle, or round-house, fitted with cross-pieces and shivers, for the conveniency of the topmasts and rigging.

Blocks, solid pieces of timber placed under the keel of the ship; the upper pieces are generally clear of knots, especially several of the foremost ones; these being the spitting blocks for launching the ship should be as clear as possible. Likewise pieces fitted with shivers, both within and without side the ship, for the use of the rigging.

A Glossary of Terms connected with the practice of Ship Building.

Bobstay-holes, those in the fore part of the knee of the head, for the security of the bobstay.

Boxing, the projection left on the hawse-pieces, in the wake of the hawse-holes, when the planks do not run through; but this is nearly laid aside in all ships, and the plank is worked through to the stem, both within and without side, which is a very great improvement; because timber, younger and smaller, will answer the same purpose, and be more durable; and by working the planks through, the bow is much stronger.

Breast hooks, pieces of compass, or knee-timber, placed within side the ship, to keep the bows together. The deck-hooks are fayed to the timber, and placed in the direction of the decks. The rest are placed, one between each deck, and as many in the hold as are thought needful; all of which should be placed square with the body of the ship, and fayed on the planks. Breast-hooks are the chief security to keep the ship's bows together, therefore require to be very strong and well secured.

Bulgeway, a large piece, or pieces bolted together making one solid piece, which is placed under the bulge of the ship to support her when launching. The support for the bulgeways to be on, is called ways, which sometimes are placed straight, and sometimes camber; but if they do camber, it should be truly circular; though sometimes the curve is quicker at the lower part, but this is liable to strain the sheer of the ship. Their extreme distance is generally about one-third the breadth of the ship, but this must depend on the form of the midship-bend.

Bulk-heads, the partitions in a ship. Those which inclose the magazine are oak plank and rabbetted, as are those of the spirituous liquor-room; others in the hold are generally oak plank, the edges are cyphered, to keep the gravel, or dirt of the ballast in the hold, from getting into the store-rooms, or into the well to damage the pumps.

Bumpkins, pieces fitted above the main-rail head, which extend nearly as far forward as the fore part of the knee of the head, and are for the use of hawling down the fore-tack.

Cat-head, a large square piece of timber fixed at the fore part of the forecastle for the use of the anchor.

Chain-bolts, those bolts which are drove through the upper end of the preventer-plates, and the toe-link of the chains.

Channels, broad planks fastened to the ship's side, to keep the shrouds at a proper distance from the side. Some channels are secured

with knees at the upper side, by which they are liable to harbour wet and dirt, which rots the channel and the ship's side: others are secured by the preventer-plates going through the channel, belayed at the under side, and the heel bolted to the ship's side.

Channel-wales, are those strakes in the top sides of large ships that are worked between the gun-deck and upper-deck ports, being thicker than the rest of the top side.

Clamps, the strake which the beams are placed upon. The upper and gun-deck clamps are generally scarfed with a hook in the middle of the scarf. The clamps lower down are not of so much consequence, being less liable to draw. In large ships there are two strakes of clamps hooked one into the other.

Companion, the birthing round the ladder-way on the quarter deck, which leads to the cabin, chiefly in small ships, to prevent the sea from beating down.

Dagger, a piece of timber that crosses all the poppets of the bulge-ways to keep them together; the plank that secures the heads of the poppets, is called the dagger-plank.

Dagger knees, are lodging-knees, whose side arms cast down, and bolt through the clamp, these are placed at the lower decks of some ships, instead of hanging knees, to preserve as much stowage in the hold as possible.

Dead-eyes, fixed in the channels, within three holds to receive the lan yard of the shrouds.

Dead-lights, shutters provided for the stern and gallery lights, to be fixed without side the ship in bad weather.

Dead-wood, pieces of timber fayed on the keel to seat the floor-timbers on, afore and abaft the floors, it is continued as high as the cutting down of the floors.

Decks in a ship are similar to floors in a house. The gun-deck of large ships is wholly laid with oak plank, nailed to the beams and tree, nailed to the ledges; those decks that are laid with deal, if intended to have standards to the side, are laid with oak so far from the side as that all the bolts in the standard shall be in the oak.

Dowsing-chocks, pieces fayed across the apron, and lapped on the knight-heads, or inside stuff above the upper deck.

Draught, the drawing or design by which the ship is to be built, which is generally by a scale of one-fourth of an inch to a foot.

Face-piece, a piece wrought on the fore part of the knee of the head, to assist the conversion of the main piece, and to shorten the upper bolts of the knee of the head.

False keel, pieces fitted under the main keel to preserve it from being rubbed, and to make the ship hold a better wind; they are generally elm. In such ships as are not intended to be frequently in harbours where they ground, the false keel is slenderly secured, that, if by accident, the ship should take the ground, it may, by coming off, be an assistant in saving her.

Fashion-pieces, the timbers that are fastened to the ends of the transoms.

Floors, the timbers which are placed across the ship, and fayed on the dead-wood. The floor-timbers are generally extended as far as the fore mast, though it should require some cant floors, if the square body does not reach so far. Abaft, the floor-timbers are seldom placed farther than where the after square frame is usually stationed; but in this part of the ship, being often difficult to procure, the floors are made in three pieces, and called made-floors, which occasions a great consumption of timber to little purpose; for the floor being designed to go in its usual place, it is made in two pieces, which butt at the middle line, or at some little distance from it, so as the bolt shall go through one-half of the floor, if thought proper; then a large chock is placed across them, and bolted to the two halves of the floor; the upper side of the chock must be kept as high as the cutting down, so that from the upper part of the chock to the head of the floor-timber, there is very little shift of timber to bolt the frame, because the lower futtock must be shortened to step on the chock; therefore it would be stronger to have a floor of natural growth, which might be procured; if one arm of the floor was no longer than the distance from the chock to the floor, as before mentioned, because the lower futtock would then extend to the dead-wood, and might be bolted through it. If a made floor is approved of in preference to that of natural growth with one short arm (either of which is immaterial in this part of the ship,) it would be best to secure the floor-ribband as far as the aft part of the square body, then put in the lower futtocks which might be bolted, to the dead-wood, and place the chock at the aft side of the lower futtocks, and bolt it to them; this would require the second futtocks to be something longer at the heels, to step on the chock, which in this part of the ship are not very difficult to procure. This method would increase the shift of timber, be much stronger, and rather in favour of the conversion of timber; because, the halves of the floor must be cut from the butts of the tree, to gain substance at the lower end; and, therefore, might be converted to a lower futtock; the regular bolting of the floor might also be preserved as the chock would be in the place

of the floor. This might be of sufficient strength in this part of the ship, if made more general, when floors of a proper growth could not be obtained.

Forecastle, a short deck at the fore part of the ship above the upper deck, on which formerly castles were erected, or places to shelter the men in time of action.

Frames, the bends of timbers that are bolted together. In small ships there are two bolts in every shift of timber, and three in large ships. The bolts should be disposed clear of the chain, and preventer-bolts, scupper, lodging-knee bolts, and port cells.

Futtock, every single timber is called a futtock, and distinguished by lower or first, second, third, &c. except the floors, long and half-timbers, top-timbers, stern-timbers, &c.

Garboard-strake, the strake in the bottom that is wrought into the rabbet of the keel.

Gunwale, the plank that covers the heads of the timbers between the fore and main drifts.

Hatches, the covering for the hatchways, made with ledges, and laid with oak or deal and calked.

Hatchways, places in the middle of the decks for the conveniency of lowering down goods.

Hawse-pieces, the timbers in the bow of the ship, whose sides are nearly parallel to the middle line of the ship.

Hold, the inside of the ship below the lower deck.

Keel, the pieces of timber laid on the blocks, and on which the ship is built; it is generally elm, except the after-piece, which, on account of its being often wet and dry, is sometimes oak, especially when the ship is expected to be a great while in building. The number of pieces in the keel is not very material, so that it gives good shift to the keelson and the main mast. The keel is scarfed with a hook in the middle, which should fay very close, it being designed on purpose to bear the strain of calking the butts, that the bolt in the scarf may not be strained. The keel should not be tapered much, either forward or aft at the upper part, and from thence it is to be bearded away at the lower edge; for when the dead-wood is trimmed, especially abaft, being frequently very thin, it is with much difficulty that the dead-wood can be securely bolted.

Keelson, pieces nearly the same scantling as the keel, wrought on the upper side of the floors, and bolted through the floors and keel. The scarfs are, if possible, disposed clear of the main and fore mast, and likewise the main hatch, as the scarf may be injured by accident

in lowering goods and heavy matters. As every other floor-timber is bolted through the keel, and the others through the keelson and keel together, it requires that the middle of the scarfs of the keelson be disposed over a floor-timber, that is designed to be bolted through the keelson.

Knees, crooked pieces of timber that secure the beams and the ship-side together: forward and abaft, where wooden knees cannot be procured of a good growth, they are made of iron; but seldom recommended in that part of the ship where strength is principally required, because the bolts cannot be drove tight in the iron knees, and, therefore, if the ship strains they will work. The lodging-knees are generally disposed on that side of the beam, which makes them the most without a square; and the hanging-knees placed clear of the ports, and of standards on the deck below. The hanging-knees are likewise placed on that side of the beam, where riders occasionally may be introduced in their stead. The lodging-knees are hooked in the beam, in general near the toe of the knee where the wood is short-grained; therefore it is better to leave a tenon in the crown part of the knee, at a proper distance from the end of the beam, which will be strong enough to bear an iron wedge drove in that side that is nearest to the ship's side, after the knees are properly bolted.

Larboard, when looking forward from the stern of the ship, it is that side of the ship towards the left-hand, or the opposite side to that usually drawn on the draught.

Limber-boards, short pieces of flank fitted from the limber-strake to the keelson, which pieces should butt at the sides of all the bulk-heads, that they may be easily taken up.

Main-breadth, the broadest part of the ship at any particular frame.

Midship-bend, the broadest frame in the ship, called dead-flat.

Munions, the pieces that part the lights in the stern and quarter-gallery.

Orlop, the lower, but temporary deck in large ships; small ships have a kind of platform in midships, chiefly for the use of the cables, which is likewise called the orlop.

Partners, are thick pieces fitted into a rabbet in the mast carlings, to receive the wedges of the mast; likewise temporary pieces nailed on the deck round the pumps.

Pump-dales, pipes to convey the water from the pump-cisterns through the ship's sides.

Quarter-deck, the short deck abaft, whereon the officers usually walk.